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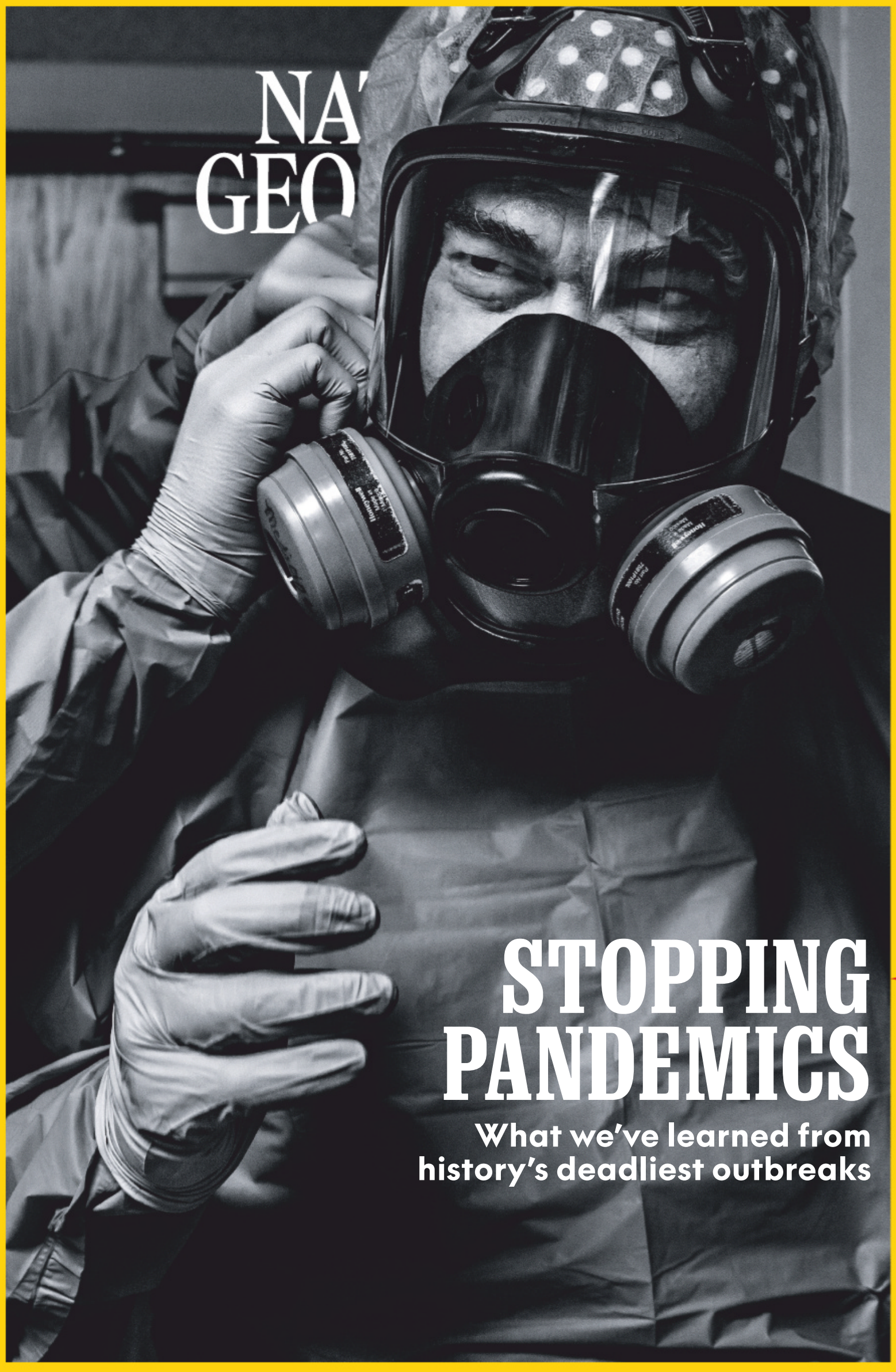

STOPPING PANDEMICS

What we've learned from history's deadliest outbreaks

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Physician Gerald Foret dons a protective mask before seeing COVID-19 patients at Our Lady of the Angels Hospital in Bogalusa, Louisiana.
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To fight COVID-19, New Yorkers stayed in, cut back on travel, and shunned gatherings, leaving a perennially busy city oddly empty.
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Stopping Pandemics
New disease outbreaks such as COVID-19 serve as harsh reminders of how easy it is for us to infect one another. Looking at previous pandemics—and the heroes that fought them—can help us understand important lessons for today. But will we remember what we learned when the danger has passed?
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Natural Uncured Pepperoni & Natural Cheese made with nothing artificial.

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STOPPING PANDEMICS

What We Don't Learn From History

BY **SUSAN GOLDBERG**

A team from FIMMG—Italy's professional association of medical doctors—performs diagnostic tests in a nursing home in Tolfa, a city north of Rome, where a staff member was found to be positive for COVID-19.

PHOTO: MASSIMO BERRUTI, MAPS

IT'S APPARENTLY humankind's fate never to stop writing the history of pandemics. No matter how often they occur—and they do occur with great frequency—we collectively refuse to think about them until circumstances demand it.

Then, when the immediate crisis passes, we put it out of our minds as quickly as possible. And so we again are unprepared when the next contagion—in this case, COVID-19—bursts upon us.

Richard Conniff traces this alarming cycle in "How Pandemics Change Us," this month's cover story. It examines our long relationship with infectious diseases, from the hard lessons we've been forced to learn to the brave, and often difficult, characters who've risked their lives to save us.

Smallpox taught us that we could prevent disease through inoculation and, as the 1700s ended, vaccination.

By the mid-1800s, cholera's lesson was about sanitation and the need for centralized water and sewer systems. About the same time, one man we've all heard of, Louis Pasteur, and one many of us haven't, Robert Koch, became the co-fathers of germ theory. Tools they created are still used to identify and fight what Conniff calls "an astonishing rogues' gallery of deadly pathogens."

And yet here we are, again, fighting on two fronts: the first, against a new coronavirus sweeping the planet to devastating effect; the second, with each other, over domestic and international politics and whether we're willing to pay the price of prevention.

As Conniff puts it: "Will a society that has barely quibbled about spending $13 billion on an aircraft carrier, largely in the service of preventing armed conflict, also accept spending on an even grander scale to prevent epidemic diseases?"

It's an important question for our planet. While we debate, the next pandemic draws nearer.

Thank you for reading *National Geographic*. ▯

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50 ctw of genuine emeralds. Enlarged to show exquisite details.

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Halfway into our ambitious trek through the rain forest I had to remind myself that "Nothing good comes easy." These days it seems that every business trip to Brazil includes a sweltering hike through overgrown jungles, around cascading waterfalls and down steep rock cliffs. But our gem broker insisted it was worth the trouble.

Now our good fortune is your great reward. Don't miss this rare opportunity to own an impressive 50 total carat strand of genuine South American emeralds for **under $100**.

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What is the source of our emerald's timeless appeal? The enchanting color of the Stauer ***Carnaval Faceted Emerald Necklace*** comes from nature's chemistry. Our polished and faceted, well-formed natural emeralds are immediately recognized as something special. Indeed, when we evaluated these emeralds, color was the most important quality factor.

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"Love it! Can't say enough about this piece. It is beautiful."

— Brenda, Yonkers, NY

Emeralds are, by weight, the most valuable gemstone in the world. Now you can wear genuine emeralds and feel great about knowing that you were able to treat yourself to precious gems without paying a precious price. A top-quality 50 carat emerald necklace found on Rodeo Drive or 5th Avenue could cost well over $100,000… but not from Stauer. Wear and admire the exquisite Stauer ***Carnaval Faceted Emerald Necklace*** for 30 days. If for any reason you are not dancing the Samba with pure satisfaction after receiving your faceted emerald necklace, simply return it to us for a full refund of the item price. But we're confident that when you examine this stunning jewelry, you'll be reminded of the raw beauty of the Amazon rain forests mixed with the flash and dazzle of the exotic Carnaval in Rio de Janeiro. Call today! This cache of genuine emeralds is extremely limited.

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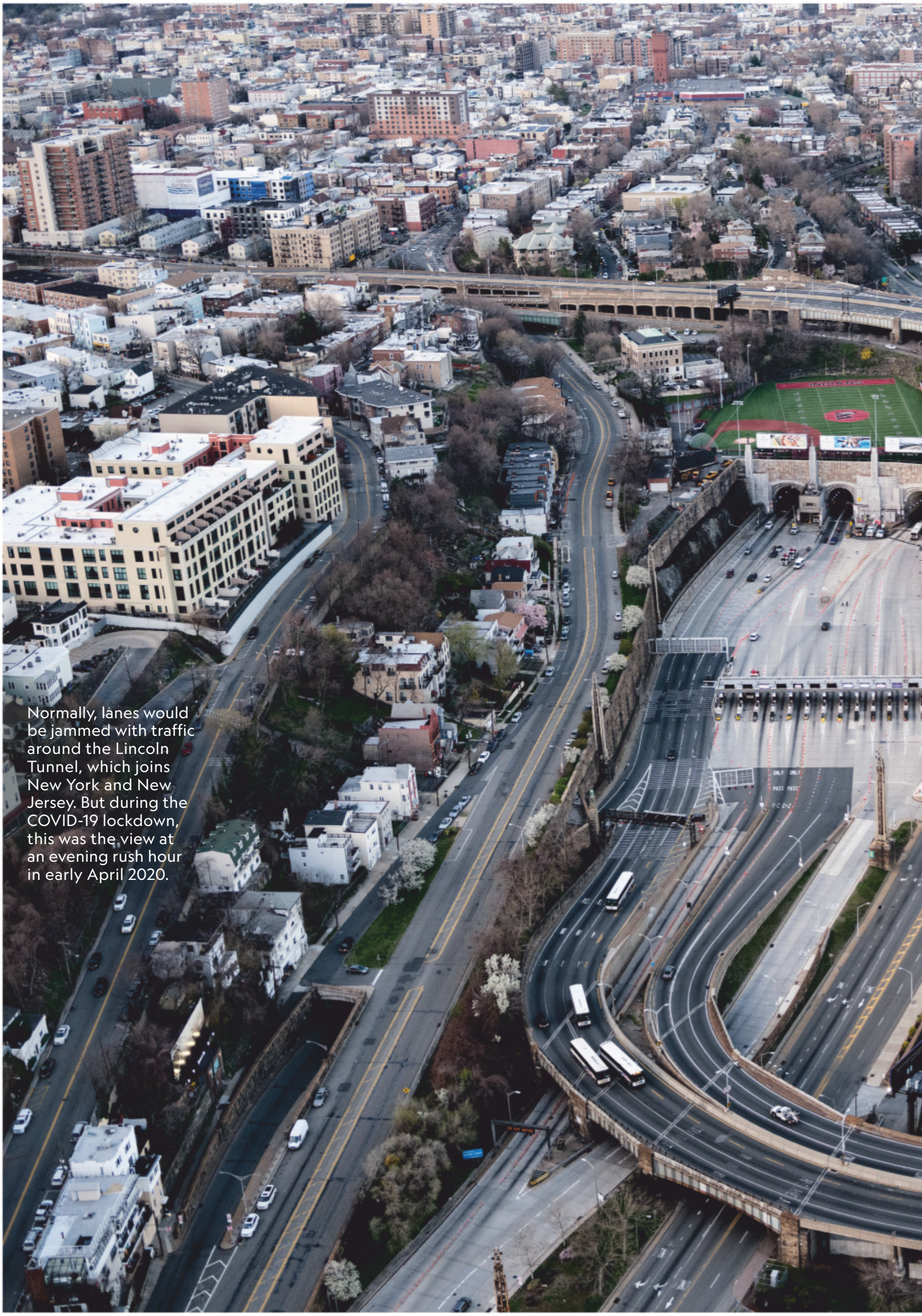
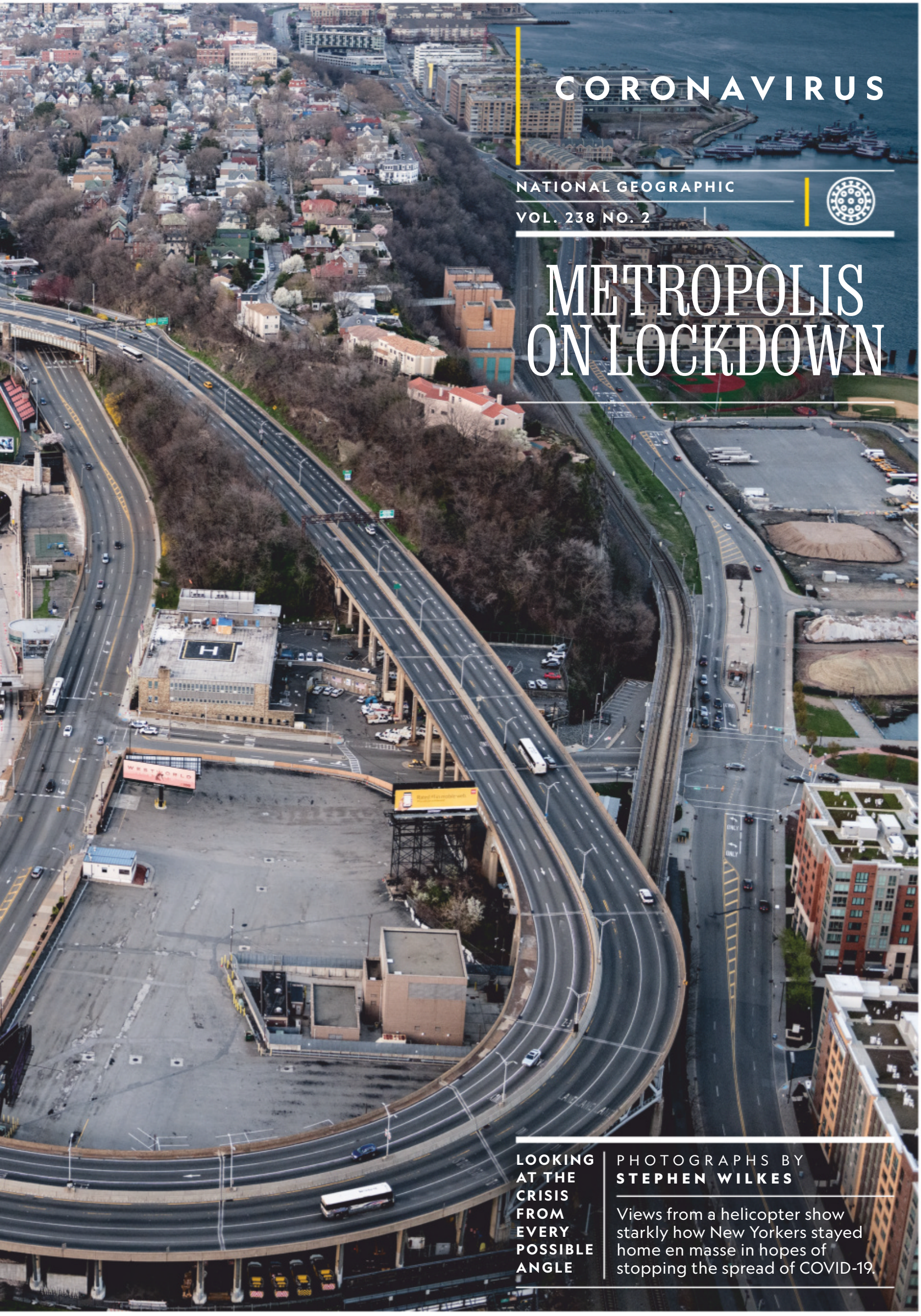


Normally, lanes would be jammed with traffic around the Lincoln Tunnel, which joins New York and New Jersey. But during the COVID-19 lockdown, this was the view at an evening rush hour in early April 2020.



CORONAVIRUS

NATIONAL GEOGRAPHIC
VOL. 238 NO. 2

METROPOLIS ON LOCKDOWN

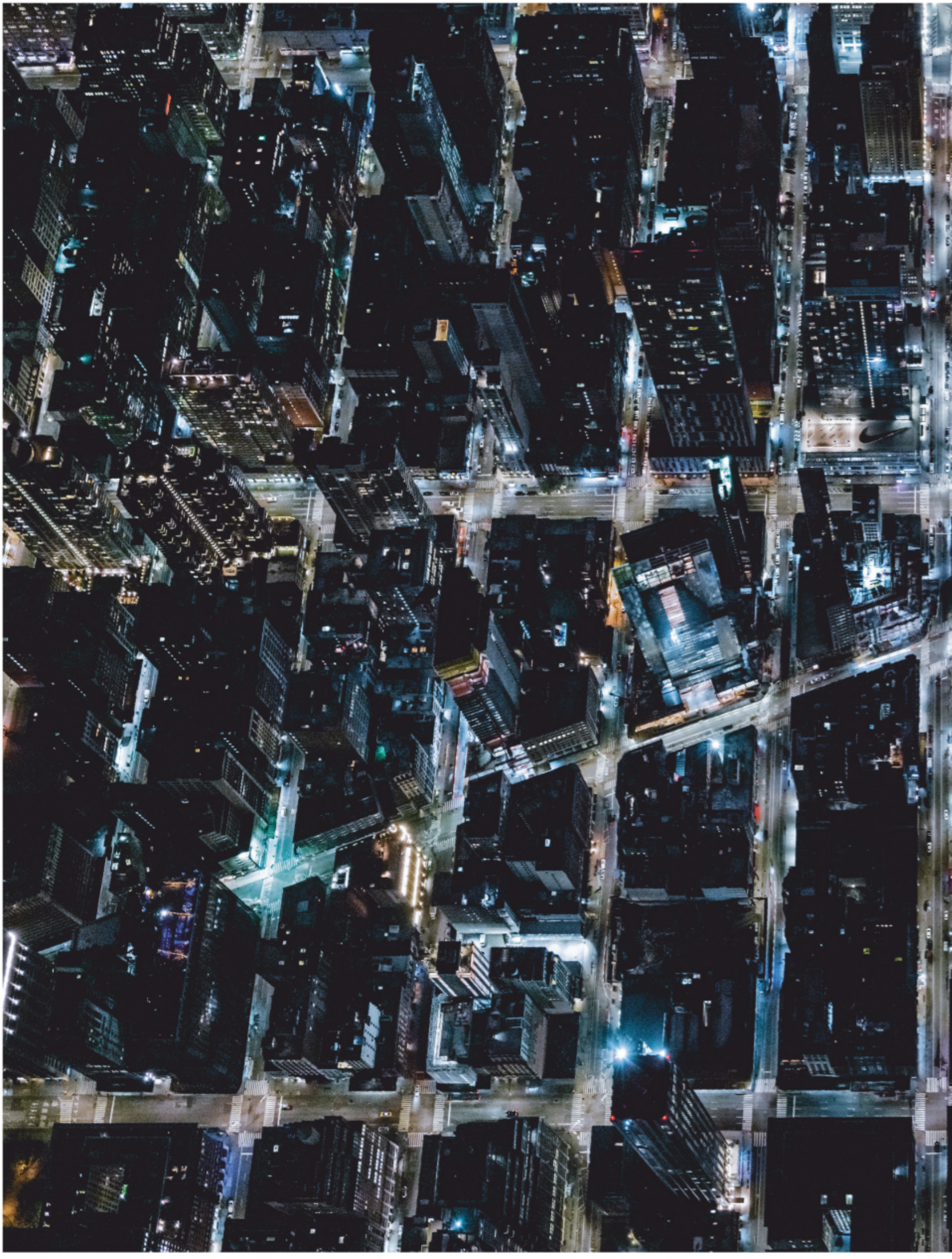
LOOKING AT THE CRISIS FROM EVERY POSSIBLE ANGLE

PHOTOGRAPHS BY **STEPHEN WILKES**

Views from a helicopter show starkly how New Yorkers stayed home en masse in hopes of stopping the spread of COVID-19.

A virtually deserted Park Avenue—normally filled with a flurry of yellow taxis, motorbike messengers, and pedestrians—is a dramatic example of how efforts to arrest the virus have emptied city centers.

Times Square is known for the sparkling ball that drops during the New Year's Eve countdown to midnight. During the pandemic, the screen beneath that ball flashes a thank-you for health care workers.



The Empire State Building—a beloved New York City landmark that for roughly 40 years held the record as tallest building in the world—is often lit in bright colors for celebrations or holidays. This spring,

the building's operators chose to light the 1,454-foot-tall building in red and white to honor the service and sacrifice of doctors and nurses.

THE BACKSTORY

NEW YORK HAS SEEN CRISES BEFORE—BUT FIGHTING THE COVID-19 PANDEMIC BROUGHT IT NEARLY TO A STANDSTILL.

STEPHEN WILKES IS a photographer, TED speaker, and creator of fine art. But at his core, he's a New Yorker. Wilkes was born in the city, and most of his life has unfolded on its streets and avenues. This identity brought extra heartache in the spring when New York earned unenviable distinction as a global hot spot and the U.S. epicenter of the COVID-19 pandemic. The "city that never sleeps" finally did—for weeks, and then, for months.

As the city went on lockdown in late March, Wilkes asked for clearance to fly over the famously protected nerve center of American commerce and culture. Officials said yes, and Wilkes and his longtime friend, pilot Al Cerullo, took a helicopter high above the avenues and subway stops. They peered down at a tent hospital in Central Park and at the occasional rooftop sunbathers and dog-walking apartment dwellers.

But mostly they saw stillness: nothing, and no one, moving. Empty streets, empty tunnels, Bryant Park without its typical midtown lunch crowd, and an absence of office workers circulating around the Empire State Building. "New York is like a river, always running with energy and motion," says Wilkes. "When you see New York empty, it doesn't make any sense."

The city will bounce back, as it has before. And when it does, Wilkes hopes it'll be as vibrant as ever. People will likely be bursting with pent-up energy, he says. But just as it did after September 11, 2001, it will also be grieving.

As Wilkes flew over Times Square—which annually hosts more than 50 million visitors and one of the world's largest New Year's Eve parties—a screen flashed a message now universally embraced: "For those fighting for our lives, thank you." —DANIEL STONE

Bryant Park, usually filled with tourists and with workers on break from the office, is seldom so empty.

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CORONAVIRUS

A SPECIAL REPORT FROM NATIONAL GEOGRAPHIC

AUGUST 2020

VOL. 238 NO. 2

When Virtual Life Turns Into Quarantine

MY GENERATION THRIVES IN THE VIRTUAL WORLD. BUT WHEN COVID-19 CUT US OFF FROM THE PHYSICAL WORLD, SOMETHING WAS LOST.

BY **OLIVER WHANG**

MY FIRST NAME COMES from the children's books about Thomas the Tank Engine, *The Railway Series*. My eldest brother had been reading the books, and Oliver the Western Engine was one of his favorites. My mother thought the name was beautiful, and so I was named after a train.

The name also served a poetic purpose: I was born an identical twin, which placed me onto a set of parallel tracks with my brother, Ethan. If you've known twins, you've heard a version of this story before. We were dressed in matching outfits, our hair cut into identical shiny black bowls. We looked the same and were treated the same, always together.

As we grew, Ethan and I were eager to establish separate identities. We made different friends, wore different clothes. In high school we often avoided talking to each other. Then we chose different colleges and were living apart for the first time in our lives.

This was exciting to me: life without a twin,

NORMAL LIFE HAS BEEN UPENDED, AND PEOPLE EVERYWHERE HAVE BEEN FORCED APART BY THE UNSEEN PERIL OF COVID-19.

without people mixing me up with someone else, without this invisible force holding us together. But the change also terrified me. Even when I had pushed Ethan away, it was comforting knowing he was there. And he was always there. Alone at college, I felt like I had lost something.

I often think about that moment of separation now, since normal life has been upended and people everywhere have been forced apart by the unseen peril of COVID-19. Suddenly the physical proximity in our day-to-day lives, which many of us took for granted, has been ripped away. I wonder what this will mean for my future, for the future in general, and for the future of my generation.

I'M STUDYING PHILOSOPHY, and in one of my first courses I came across a thought experiment, devised by philosopher Frank Jackson, that's widely known as Mary's Room. The premise is that Mary, a brilliant scientist, has lived her whole life in a colorless room where her only sensory input is through a black-and-white television screen.

Mary has access to tons of information and knows everything about color perception; she's just never experienced it. Then one day, let's say she walks out of the room—sees the blue sky, feels the bark of a tree. Jackson's question is: Does she learn anything new? Does experiencing the world tell us something that we couldn't have learned by reading up on it?

Jackson says yes. Those things we miss by not living in the physical world he calls qualia, and they're everywhere—in the sun, the earth, other people. They're what's lacking in a strictly virtual life.

For years I've had this nagging intuition that almost everything I need to do can be done virtually. I can talk to my friends, write, read, report stories, watch television, listen to a lecture, scroll through social media. When all my university's classes went online in late March, there were actually *more* things I could do. My professors were more available online. I had fewer distractions and easier access to a lot of materials.

In lockdown, I moved back to my family home but my life went on much as it was. My mother, a therapist, still sees her patients; my sister uses Zoom for her high school classes. It's just all virtual, a different reality.

This kind of virtual life is home turf to my generation. I grew up with computers; I got bigger as they got smaller and more accessible. My peers learned how to surf the internet before our parents, figured out how to flirt through text messages, formed cliques with instant-messaging group chats. Even before

ILLUSTRATION: BIANCA BAGNARELLI

the pandemic, I spent some Saturday nights alone in my room, face lit by the glowing screens of my laptop and phone, chatting with friends online and watching sports highlights.

After college, I'll enter an increasingly virtual workforce. Computers are—or will be—replacing humans across the economy: bankers, truck drivers, factory workers. Many of the jobs that aren't disappearing are moving online. I assume that most of my friends will work in professions that involve staring at computer screens or talking on phones. As a writer, I could end up working from home every day. I'm already spending half my life online, so that prospect doesn't feel all that jarring. Still, it's a pretty strange reality.

FOR MANY YOUNG PEOPLE LIKE ME—with healthy bodies and outsize beliefs of invincibility—the primary fear hasn't been that we will contract the virus. What we fear more is the profound uncertainty of our future. There are a lot of frightening possibilities; new ones seem to emerge every day. But I think the scariest possibility—beyond this disease never going away—is that this ubiquity of virtual living might never go away either.

I worry that the experience of this pandemic might convince people that we can keep living just fine while physically isolated from others. I find myself slipping toward that reality. There are entire days when I don't leave the house, when my only human contact is with my brother as we await a turn in the bathroom.

What if this level of isolation is the future? In this environment, something clearly is lost. I'm sure of it, because I feel different when I experience things directly rather than virtually.

In some ways, being apart brought Ethan and me closer together. Once we were at colleges in different states, we began calling each other. I can't remember who called who first, and we never talked about emotions, or about girls, or about philosophy. We'd just give little updates: "I haven't slept in 24 hours." "I just killed a huge burger."

I'd never say this to him now—it's too cheesy—but it's true: The distance allowed us to figure out what we actually like about each other. So we gained something by crossing the miles virtually.

There's something you can't simulate, though, about the physical presence of another human being. No screen will ever replace the feeling of an arm around your shoulders. At the end of my long-distance chats with Ethan, he'd hang up, and I'd be alone again in my room, staring at a blank screen.

I WORRY THAT THE EXPERIENCE OF THIS PANDEMIC MIGHT CONVINCE PEOPLE THAT WE CAN KEEP LIVING JUST FINE WHILE PHYSICALLY ISOLATED FROM OTHERS.

My fear is that, going forward, some of us will never completely come out of self-quarantine; that dread and uncertainty will cause us to lose part of our physical connection to the world. The qualia.

ETHAN AND I ARE living together again for now, back in our childhood home. We are forced together—along with my mother, father, sister, older brother and his girlfriend—just as the rest of the world is being forced apart. Proximity with my twin isn't bothersome anymore. We stay up late playing video games, cracking jokes, belly-laughing softly so we don't wake others. It's nice, not being alone.

We still rarely talk about serious topics. When I told Ethan about Mary's Room, he just shrugged: "Yeah, I guess it makes sense." I was relieved. Ethan often makes fun of my philosophizing. I'll go on and on, confident that I'm exposing some deeper truth, and he'll say, "That's just stupid, dude."

But our relationship isn't about what's said; it's about being connected. In the spring we bleached our hair together, in the same sink, turning it from black to almost white. I don't really know why we did it—it was Ethan's idea. We look the same now, but different.

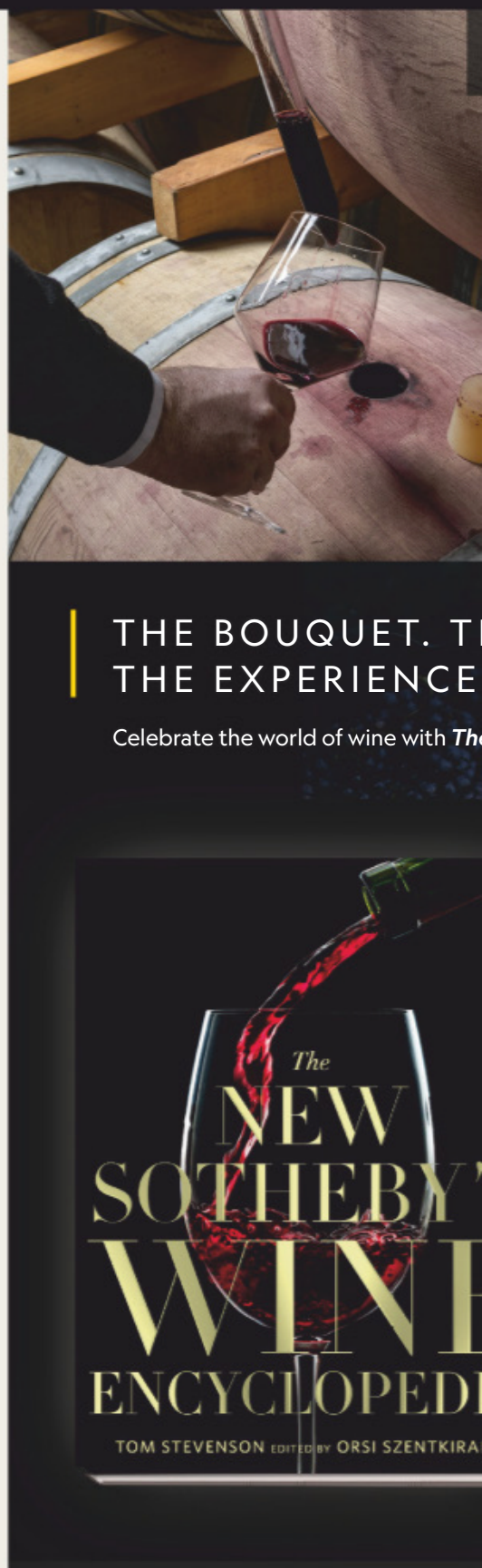
On a warm night a few weeks into the pandemic, we walked out to the train tracks behind our house and tried to balance on the thin metal rails, as we did sometimes when we were kids. Ethan was much better at this than I was. I kept falling off the side, losing my balance; Oliver the Western Engine, derailed.

Ethan, though, could keep going for minutes at a time. Occasionally, we'd end up next to each other and walk forward for a moment, together. The way was dark ahead of us, a little scary. But some kind of instinct kept us going, and we moved ahead on parallel tracks. ▯

Whang (second from left) poses with fellow staffers of radio station WPRB.

Had COVID-19 not canceled National Geographic's summer internships, **Oliver Whang** would have been in Washington, D.C., working on our podcast, *Overheard at National Geographic*. Instead, he's at home in New Jersey, freelance writing and preparing for his senior year at Princeton, where he'll be news director for the campus public radio station, WPRB.

PHOTO: OLIVER WHANG



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This head shape (dark), sketched in the 1600s, has long served as the dodo's artistic—and inaccurate—image.

Old representation

Modern representation in actual size

THE DODO'S NEW LOOK

BY **FERNANDO G. BAPTISTA** AND **PATRICIA HEALY**

A PICTURE OF THE EXTINCT, flightless bird that has inspired artists and tall tales for centuries is slowly coming into sharper relief. Modern scientific tools and newly discovered bones, in combination with historic sightings and previously studied specimens, are giving scientists fresh insights into the mysterious bird's anatomy and life cycle on Mauritius, where it once thrived.

THROUGH THE LOOKING GLASS

Based on early mariner accounts, sketches, and paintings of dodoes in captivity, the bird's image took a fantastical turn. In the 1600s, portraits of comical, squat birds became the standard for future classics such as *Alice's Adventures in Wonderland.*

A YEAR IN THE LIFE

Recent discoveries help explain how the dodo—smarter and sleeker than once thought—had adapted to its cyclone-prone environment. Then in 1598, Europeans, rats, and pigs arrived in Mauritius and drove dodoes to extinction.

- **Extinct species**
- **Extinct on Mauritius**

Broad-billed parrot
Lophopsittacus mauritianus

Giant skink
Leiolopisma mauritiana

Mauritius giant flat-shelled tortoise
Cylindraspis triserrata

Egg
1
Nest
Chick
2
3
4 Adult height 3 ft
5 Molting (dark brown)
6
7 Fully feathered (gray)

AUSTRAL SUMMER CYCLONE SEASON

August | September | October | November | December | January | February | March | April | May

BREEDING

Females began to ovulate in August. Nests were built on the ground, per firsthand accounts; the size, shape, and number of eggs are unknown.

GROWING QUICKLY

Chicks hatched and grew to near adult size within months, perhaps to better survive cyclone season in the summer.

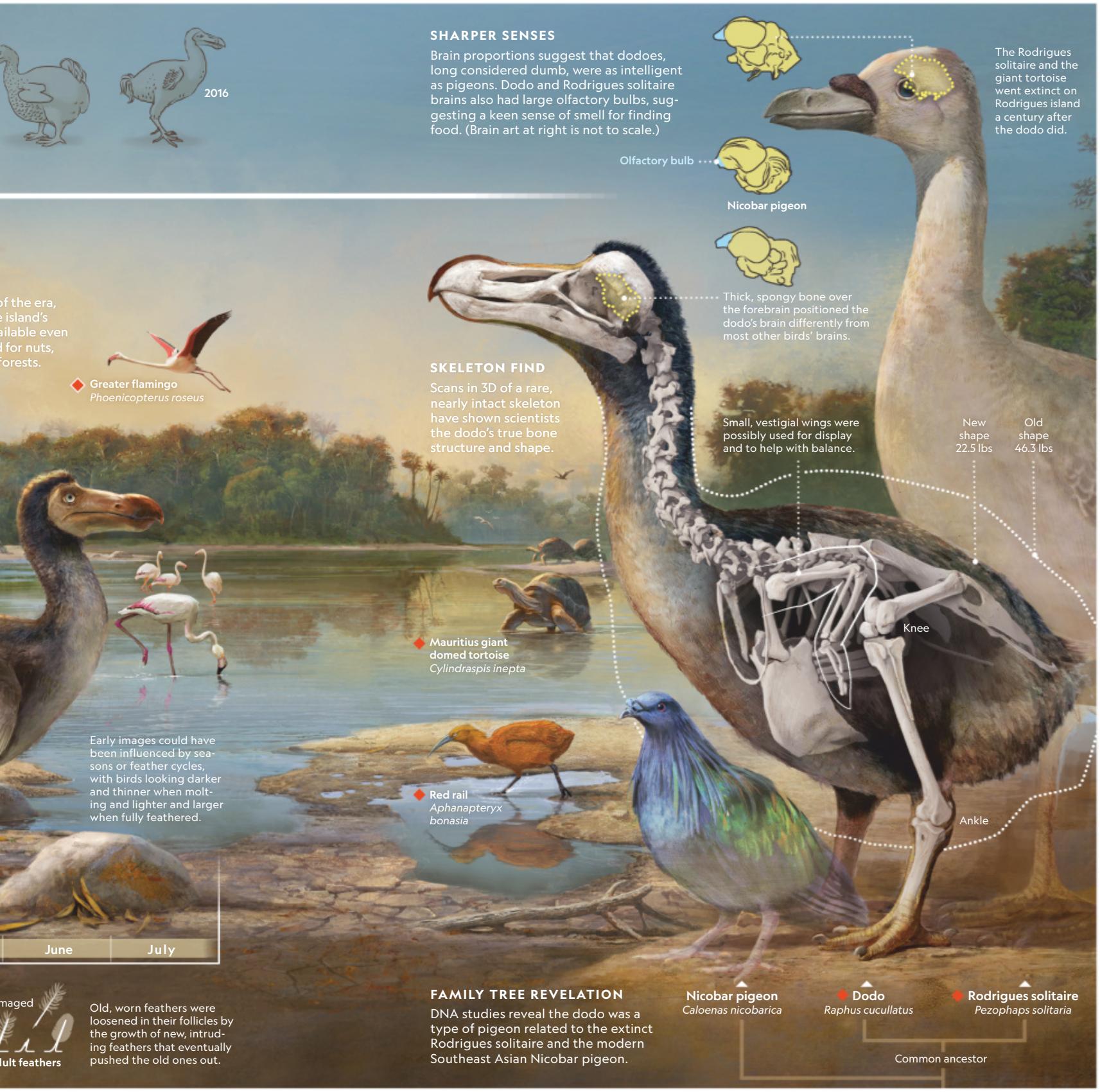
CHANGING FEATHERS

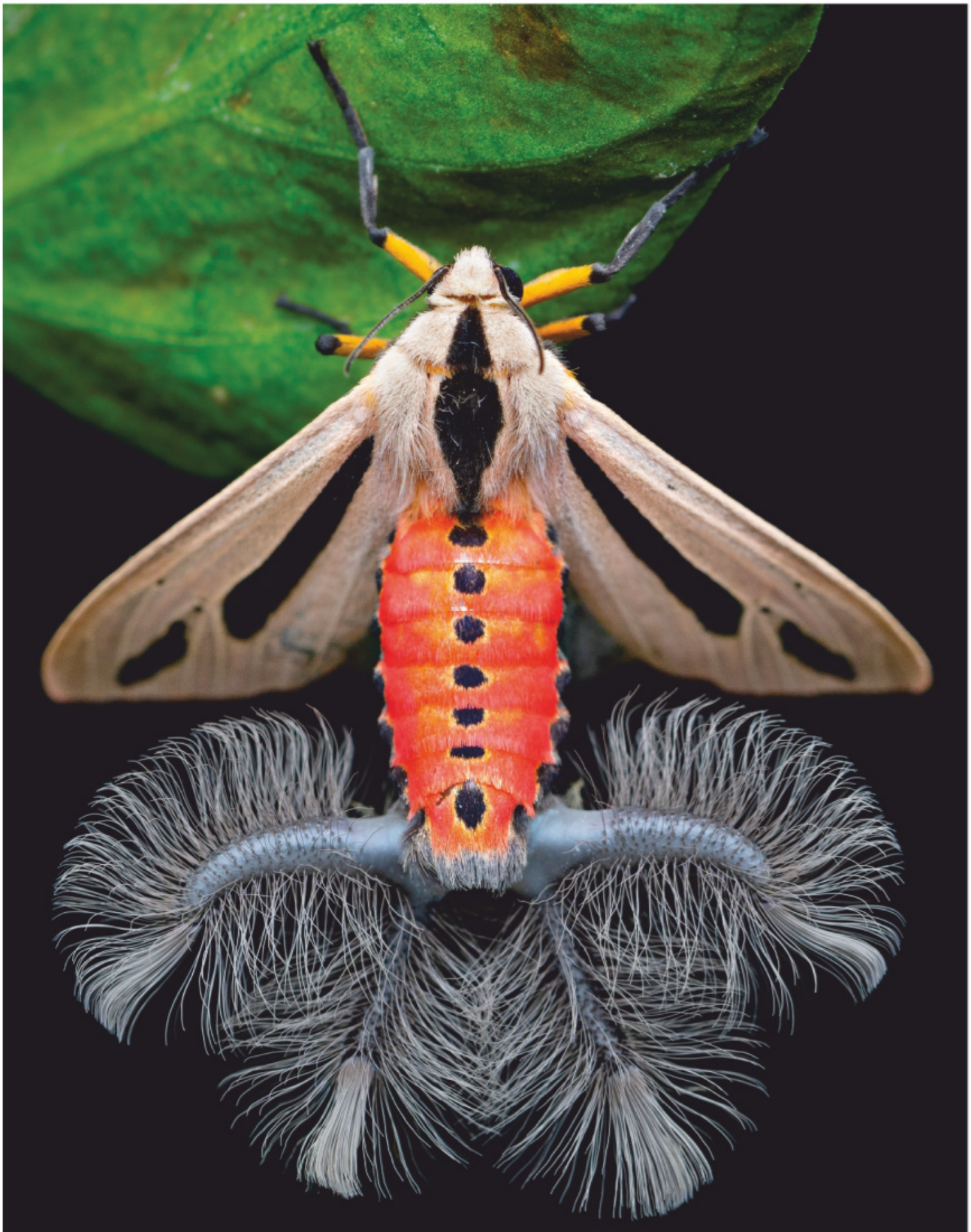
Molting dodoes looked as disheveled as their environment during cyclone season. As conditions improved, new feathers began to replace the old.

RICH ECOSYSTEM

Like many other creatures o the dodo depended on the freshwater pools—often ava during droughts. It forageo fruits, and seeds in nearby f

EVE CONANT, NGM STAFF. SOURCES: DELPHINE ANGST, UNIVERSITY OF BRISTOL; LEON CLAESSENS, MAASTRICHT UNIVERSITY; M. EUGENIA L. GOLD, SUFFOLK UNIVERSITY; DURBAN NATURAL SCIENCE MUSEUM AND AVES 3D; JULIAN HUME, NATURAL HISTORY MUSEUM, LONDON; ANDREW IWANIUK, UNIVERSITY OF LETHBRIDGE; STIG WALSH, NATIONAL MUSEUMS SCOTLAND; RAFFAEL WINKLER, NATURAL HISTORY MUSEUM BASEL; AGNÈS ANGST (MODERN DODO)


2016
SHARPER SENSES
Brain proportions suggest that dodoes, long considered dumb, were as intelligent as pigeons. Dodo and Rodrigues solitaire brains also had large olfactory bulbs, suggesting a keen sense of smell for finding food. (Brain art at right is not to scale.)
Olfactory bulb
Nicobar pigeon
The Rodrigues solitaire and the giant tortoise went extinct on Rodrigues island a century after the dodo did.
Thick, spongy bone over the forebrain positioned the dodo's brain differently from most other birds' brains.
of the era,
e island's
ailable even
d for nuts,
forests.
Greater flamingo
Phoenicopterus roseus
SKELETON FIND
Scans in 3D of a rare, nearly intact skeleton have shown scientists the dodo's true bone structure and shape.
Small, vestigial wings were possibly used for display and to help with balance.
New shape 22.5 lbs
Old shape 46.3 lbs
Knee
Ankle
Mauritius giant domed tortoise
Cylindraspis inepta
Red rail
Aphanapteryx bonasia
Early images could have been influenced by seasons or feather cycles, with birds looking darker and thinner when molting and lighter and larger when fully feathered.
June
July
maged
dult feathers
Old, worn feathers were loosened in their follicles by the growth of new, intruding feathers that eventually pushed the old ones out.
FAMILY TREE REVELATION
DNA studies reveal the dodo was a type of pigeon related to the extinct Rodrigues solitaire and the modern Southeast Asian Nicobar pigeon.
Nicobar pigeon
Caloenas nicobarica
Dodo
Raphus cucullatus
Rodrigues solitaire
Pezophaps solitaria
Common ancestor



TO ATTRACT THE LADIES, A MALE MOTH FLASHES THIS

PHOTOGRAPH BY
KHALID ABDULLAH SAID ALHADHRAMI

A male *Creatonotos* moth inflates his bushy behind only at mating time, and for one purpose: to lure females. The tubular organs are coated in bristles that emit pheromones. The more toxic plants the males eat as larvae, the bigger and more potent these organs will be. –MAYA WEI-HAAS

DISPATCHES
FROM THE FRONT LINES
OF SCIENCE
AND INNOVATION

Medicinal uses are mushrooming

Patients in a pilot study felt decreased symptoms of anxiety and depression for at least one week after taking a large dose of psilocybin, the hallucinogen in magic mushrooms. The study findings, published in *Scientific Reports,* suggest that the drug may support an "enduring shift" away from negative moods and cravings. –PATRICIA EDMONDS

ANIMALS

HOW CAN INSECTS TURN COLORS THEY CAN'T SEE?

RESEARCH ON THESE CHAMELEON-LIKE LARVAE SHOWS THEY 'SEE' WITH MORE THAN THEIR EYES.

PEPPERED MOTHS ARE MASTERS of camouflage. In the larval stage, they can change the color of their skin to blend into their settings—even without seeing those surroundings, a new study found. After raising more than 300 peppered moth larvae, U.K. researchers obscured the vision of some with black paint (which the larvae later shed, unharmed). The larvae were placed in boxes containing white, green, brown, or black sticks, and given time to adapt. When the researchers opened the boxes, they found that nearly all the caterpillars, with or without vision, had changed their body colors to match the sticks in their box. The researchers then moved the caterpillars into new boxes containing sticks of two different colors, and about 80 percent of the insects chose to rest on sticks that matched their body color. The researchers say their findings provide strong evidence that peppered moth larvae are capable of dermal photoreception—seeing with their skin. –ANNIE ROTH

GREEN TECH

Cement of the future?

The process for making cement creates so much greenhouse gas that if it were a country, it'd be the third largest emitter on Earth. That statistic is from MIT, where scientists devised a process that would produce cement using electricity, rather than by burning fossil fuels. In a water electrolyzer (below), current to the electrodes creates hydrogen and oxygen gases, an acid, and a base. When limestone is added to the acid, it's dissolved and decarbonated—loses its CO_2—and then can be used to make a key cement ingredient. –AR

PAUL STAMETS (MUSHROOMS); ILIK SACCHERI (CATERPILLARS), BRIAN CHAN (HEAD), INSTITUTE OF INTEGRATIVE BIOLOGY, UNIVERSITY OF LIVERPOOL; FELICE FRANKEL, MIT

KEYTRUDA IS BREAKING THROUGH BARRIERS IN ADVANCED LUNG CANCER TREATMENT.

FOR TODAY

KEYTRUDA is a potential first treatment for **3 out of 4 patients** with advanced non–small cell lung cancer (NSCLC).

KEYTRUDA also has **more FDA-approved uses** for advanced lung cancer than any other immunotherapy.

FOR THE FUTURE

Ongoing clinical trials are exploring if KEYTRUDA can help treat more patients.

Ask your doctor if KEYTRUDA is right for you. **Visit keytruda.com/lung**

KEYTRUDA is a prescription medicine used to treat a kind of lung cancer called non–small cell lung cancer (NSCLC).

- **KEYTRUDA + CHEMOTHERAPY, NONSQUAMOUS**
  It may be used with the chemotherapy medicines pemetrexed and a platinum as your first treatment when your lung cancer has spread (advanced NSCLC) **and** is a type called "nonsquamous" **and** your tumor does not have an abnormal "EGFR" or "ALK" gene.
- **KEYTRUDA + CHEMOTHERAPY, SQUAMOUS**
  It may be used with the chemotherapy medicines carboplatin and either paclitaxel or paclitaxel protein-bound as your first treatment when your lung cancer has spread (advanced NSCLC), **and** is a type called "squamous."
- **KEYTRUDA USED ALONE, PD-L1 POSITIVE**
  It may be used alone as your first treatment when your lung cancer has not spread outside your chest (stage III) and you cannot have surgery or chemotherapy with radiation, **or** your NSCLC has spread to other areas of your body (advanced NSCLC), **and** your tumor tests positive for "PD-L1" **and** does not have an abnormal "EGFR" or "ALK" gene.
- **KEYTRUDA AFTER CHEMOTHERAPY, PD-L1 POSITIVE**
  It may also be used alone for advanced NSCLC if you have tried chemotherapy that contains platinum and it did not work or is no longer working **and**, your tumor tests positive for "PD-L1" **and** if your tumor has an abnormal "EGFR" or "ALK" gene, you have also received an "EGFR" or "ALK" inhibitor medicine that did not work or is no longer working.

PD-L1 = programmed death ligand 1;
EGFR = epidermal growth factor receptor;
ALK = anaplastic lymphoma kinase.

IMPORTANT SAFETY INFORMATION

KEYTRUDA is a medicine that may treat certain cancers by working with your immune system. KEYTRUDA can cause your immune system to attack normal organs and tissues in any area of your body and can affect the way they work. These problems can sometimes become severe or life-threatening and can lead to death. These problems may happen any time during treatment or even after your treatment has ended.

Call or see your doctor right away if you develop any symptoms of the following problems or these symptoms get worse:

- **Lung problems (pneumonitis).** Symptoms of pneumonitis may include shortness of breath, chest pain, or new or worse cough.
- **Intestinal problems (colitis) that can lead to tears or holes in your intestine.** Signs and symptoms of colitis may include diarrhea or more bowel movements than usual; stools that are black, tarry, sticky, or have blood or mucus; or severe stomach-area (abdomen) pain or tenderness.
- **Liver problems, including hepatitis.** Signs and symptoms of liver problems may include yellowing of your skin or the whites of your eyes, nausea or vomiting, pain on the right side of your stomach area (abdomen), dark urine, or bleeding or bruising more easily than normal.
- **Hormone gland problems (especially the thyroid, pituitary, adrenal glands, and pancreas).** Signs and symptoms that your hormone glands are not working properly may include rapid heartbeat, weight loss or weight gain, increased sweating, feeling more hungry or thirsty, urinating more often than usual, hair loss, feeling cold, constipation, your voice gets deeper, muscle aches, feeling very weak, dizziness or fainting, or headaches that will not go away or unusual headache.
- **Kidney problems, including nephritis and kidney failure.** Signs of kidney problems may include change in the amount or color of your urine.
- **Skin problems.** Signs of skin problems may include rash, itching, blisters, peeling or skin sores, or painful sores or ulcers in your mouth or in your nose, throat, or genital area.
- **Problems in other organs.** Signs and symptoms of these problems may include changes in eyesight; severe or persistent muscle or joint pains; severe muscle weakness; low red blood cells (anemia); swollen lymph

Important Safety Information is continued on the next page.

keytruda.com/lung

IMPORTANT SAFETY INFORMATION ***(continued)***

nodes, rash or tender lumps on skin, cough, shortness of breath, vision changes, or eye pain (sarcoidosis); confusion, fever, muscle weakness, balance problems, nausea, vomiting, stiff neck, memory problems, or seizures (encephalitis); and shortness of breath, irregular heartbeat, feeling tired, or chest pain (myocarditis).

- **Infusion (IV) reactions that can sometimes be severe and life-threatening.** Signs and symptoms of infusion reactions may include chills or shaking, shortness of breath or wheezing, itching or rash, flushing, dizziness, fever, or feeling like passing out.
- **Rejection of a transplanted organ.** People who have had an organ transplant may have an increased risk of organ transplant rejection if they are treated with KEYTRUDA.
- **Complications, including graft-versus-host disease (GVHD), in people who have received a bone marrow (stem cell) transplant that uses donor stem cells (allogeneic).** These complications can be severe and can lead to death. These complications may happen if you underwent transplantation either before or after being treated with KEYTRUDA. Your doctor will monitor you for the following signs and symptoms: skin rash, liver inflammation, abdominal pain, and diarrhea.

Getting medical treatment right away may help keep these problems from becoming more serious. Your doctor will check you for these problems during treatment with KEYTRUDA. Your doctor may treat you with corticosteroid or hormone replacement medicines. Your doctor may also need to delay or completely stop treatment with KEYTRUDA if you have severe side effects.

Before you receive KEYTRUDA, tell your doctor if you have immune system problems such as Crohn's disease, ulcerative colitis, or lupus; have had an organ transplant or plan to have or have had a bone marrow (stem cell) transplant that used donor stem cells (allogeneic); have lung or breathing problems; have liver problems; or have any other medical problems.

If you are pregnant or plan to become pregnant, tell your doctor. KEYTRUDA can harm your unborn baby. If you are able to become pregnant, your doctor will give you a pregnancy test before you start treatment. Use effective birth control during treatment and for at least 4 months after the final dose of KEYTRUDA. Tell your doctor right away if you think you may be pregnant or you become pregnant during treatment with KEYTRUDA.

If you are breastfeeding or plan to breastfeed, tell your doctor. It is not known if KEYTRUDA passes into your breast milk. Do not breastfeed during treatment with KEYTRUDA and for 4 months after your final dose of KEYTRUDA.

Tell your doctor about all the medicines you take, including prescription and over-the-counter medicines, vitamins, and herbal supplements.

Common side effects of KEYTRUDA when used alone include feeling tired; pain, including pain in muscles, bones, or joints and stomach area (abdominal) pain; decreased appetite; itching; diarrhea; nausea; rash; fever; cough; shortness of breath; and constipation.

Common side effects of KEYTRUDA when given with certain chemotherapy medicines include feeling tired or weak; nausea; constipation; diarrhea; decreased appetite; rash; vomiting; cough; trouble breathing; fever; hair loss; inflammation of the nerves that may cause pain, weakness, and paralysis in the arms and legs; swelling of the lining of the mouth, nose, eyes, throat, intestines, or vagina; and mouth sores.

These are not all the possible side effects of KEYTRUDA. Tell your doctor if you have any side effect that bothers you or that does not go away. For more information, ask your doctor or pharmacist.

Please read the adjacent Important Information About KEYTRUDA and discuss it with your oncologist.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

Having trouble paying for your Merck medicine?
Merck may be able to help. www.merckhelps.com

IT'S TRU. KEYTRUDA® (pembrolizumab) Injection 100 mg

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Important Information About KEYTRUDA® (pembrolizumab) injection 100 mg.
Please speak with your healthcare professional regarding KEYTRUDA (pronounced key-true-duh).
Only your healthcare professional knows the specifics of your condition and how KEYTRUDA may work with your overall treatment plan. If you have any questions about KEYTRUDA, speak with your healthcare professional. **℞ ONLY**

What is the most important information I should know about KEYTRUDA?
KEYTRUDA is a medicine that may treat certain cancers by working with your immune system. KEYTRUDA can cause your immune system to attack normal organs and tissues in any area of your body and can affect the way they work. These problems can sometimes become severe or life-threatening and can lead to death. These problems may happen anytime during treatment or even after your treatment has ended.

Call or see your doctor right away if you develop any symptoms of the following problems or these symptoms get worse:
Lung problems (pneumonitis). Symptoms of pneumonitis may include:
- shortness of breath
- chest pain
- new or worse cough

Intestinal problems (colitis) that can lead to tears or holes in your intestine. Signs and symptoms of colitis may include:
- diarrhea or more bowel movements than usual
- stools that are black, tarry, sticky, or have blood or mucus
- severe stomach-area (abdomen) pain or tenderness

Liver problems, including hepatitis. Signs and symptoms of liver problems may include:
- yellowing of your skin or the whites of your eyes
- nausea or vomiting
- pain on the right side of your stomach area (abdomen)
- dark urine
- bleeding or bruising more easily than normal

Hormone gland problems (especially the thyroid, pituitary, adrenal glands, and pancreas). Signs and symptoms that your hormone glands are not working properly may include:
- rapid heart beat
- weight loss or weight gain
- increased sweating
- feeling more hungry or thirsty
- urinating more often than usual
- hair loss
- feeling cold
- constipation
- your voice gets deeper
- muscle aches
- feeling very weak
- dizziness or fainting
- headaches that will not go away or unusual headache

Kidney problems, including nephritis and kidney failure. Signs of kidney problems may include:
- change in the amount or color of your urine

Skin problems. Signs of skin problems may include:
- rash
- itching
- blisters, peeling or skin sores
- painful sores or ulcers in your mouth or in your nose, throat, or genital area

Problems in other organs. Signs and symptoms of these problems may include:
- changes in eyesight
- severe or persistent muscle or joint pains
- severe muscle weakness
- low red blood cells (anemia)
- swollen lymph nodes, rash or tender lumps on skin, cough, shortness of breath, vision changes, or eye pain (sarcoidosis)
- confusion, fever, muscle weakness, balance problems, nausea, vomiting, stiff neck, memory problems, or seizures (encephalitis)
- shortness of breath, irregular heartbeat, feeling tired, or chest pain (myocarditis)

Infusion (IV) reactions that can sometimes be severe and life-threatening. Signs and symptoms of infusion reactions may include:
- chills or shaking
- shortness of breath or wheezing
- itching or rash
- flushing
- dizziness
- fever
- feeling like passing out

Rejection of a transplanted organ. People who have had an organ transplant may have an increased risk of organ transplant rejection. Your doctor should tell you what signs and symptoms you should report and monitor you, depending on the type of organ transplant that you have had.

Complications, including graft-versus-host-disease (GVHD), in people who have received a bone marrow (stem cell) transplant that uses donor stem cells (allogeneic). These complications can be severe and can lead to death. These complications may happen if you underwent transplantation either before or after being treated with KEYTRUDA. Your doctor will monitor you for the following signs and symptoms: skin rash, liver inflammation, stomach-area (abdominal) pain, and diarrhea.

Getting medical treatment right away may help keep these problems from becoming more serious. Your doctor will check you for these problems during treatment with KEYTRUDA. Your doctor may treat you with corticosteroid or hormone replacement medicines. Your doctor may also need to delay or completely stop treatment with KEYTRUDA, if you have severe side effects.

What should I tell my doctor before receiving KEYTRUDA?
Before you receive KEYTRUDA, tell your doctor if you:

- have immune system problems such as Crohn's disease, ulcerative colitis, or lupus
- have received an organ transplant, such as a kidney or liver
- have received or plan to receive a stem cell transplant that uses donor stem cells (allogeneic)
- have lung or breathing problems
- have liver problems
- have any other medical problems
- are pregnant or plan to become pregnant
  - KEYTRUDA can harm your unborn baby.

Females who are able to become pregnant:

- Your doctor will give you a pregnancy test before you start treatment with KEYTRUDA.
- You should use an effective method of birth control during and for at least 4 months after the final dose of KEYTRUDA. Talk to your doctor about birth control methods that you can use during this time.
- Tell your doctor right away if you think you may be pregnant or if you become pregnant during treatment with KEYTRUDA.

- are breastfeeding or plan to breastfeed.
  - It is not known if KEYTRUDA passes into your breast milk.
  - Do not breastfeed during treatment with KEYTRUDA and for 4 months after your final dose of KEYTRUDA.

Tell your doctor about all the medicines you take, including prescription and over-the-counter medicines, vitamins, and herbal supplements.

Know the medicines you take. Keep a list of them to show your doctor and pharmacist when you get a new medicine.

How will I receive KEYTRUDA?

- Your doctor will give you KEYTRUDA into your vein through an intravenous (IV) line over 30 minutes.
- KEYTRUDA is usually given every 3 weeks.
- Your doctor will decide how many treatments you need.
- Your doctor will do blood tests to check you for side effects.
- If you miss any appointments, call your doctor as soon as possible to reschedule your appointment.

What are the possible side effects of KEYTRUDA?
KEYTRUDA can cause serious side effects. See "What is the most important information I should know about KEYTRUDA?"

Common side effects of KEYTRUDA when used alone include: feeling tired, pain, including pain in muscles, bones or joints and stomach-area (abdominal) pain, decreased appetite, itching, diarrhea, nausea, rash, fever, cough, shortness of breath, and constipation.

Common side effects of KEYTRUDA when given with certain chemotherapy medicines include: feeling tired or weak, nausea, constipation, diarrhea, decreased appetite, rash, vomiting, cough, trouble breathing, fever, hair loss, inflammation of the nerves that may cause pain, weakness, and paralysis in the arms and legs, swelling of the lining of the mouth, nose, eyes, throat, intestines, or vagina, and mouth sores.

Common side effects of KEYTRUDA when given with axitinib include: diarrhea, feeling tired or weak, high blood pressure, liver problems, low levels of thyroid hormone, decreased appetite, blisters or rash on the palms of your hands and soles of your feet, nausea, mouth sores or swelling of the lining of the mouth, nose, eyes, throat, intestines, or vagina, hoarseness, rash, cough, and constipation.

In children, feeling tired, vomiting and stomach-area (abdominal) pain, and increased levels of liver enzymes and decreased levels of salt (sodium) in the blood are more common than in adults.

These are not all the possible side effects of KEYTRUDA. For more information, ask your doctor or pharmacist.

Tell your doctor if you have any side effect that bothers you or that does not go away.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

General information about the safe and effective use of KEYTRUDA
Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. If you would like more information about KEYTRUDA, talk with your doctor. You can ask your doctor or nurse for information about KEYTRUDA that is written for healthcare professionals.

For more information, go to www.keytruda.com.

Based on Medication Guide usmg-mk3475-iv-2001r029 as revised January 2020.

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MERCK

IN BLACK AND WHITE, SLOWLY

PHOTOGRAPH BY **MARK THIESSEN**

1. Print developing tray
Three trays—develop, stop, and fix—hold chemicals needed to make a print.
2. Rubber-tipped tongs
Without them, your fingernails would turn black from the chemicals.
3. Thermometer
A single-degree shift in the chemicals can alter how a negative develops.
4. Dodging tools
As the film is projected onto paper and exposed, moving the tools over dark areas reveals detail.
5. Squeegee
It removes rinse water from a developed print.
6. Timer
A print stays in the developer chemical for 90 seconds to three minutes.
7. Grain focuser
This tool zooms in to ensure the negative's grain is projected sharply.
8. Antistatic brush
The negative must be swept clear of dust.
9. Loupe
Magnifying the negative shows scratches or specks.
10. Negative carrier
Inserted into the enlarger, this holds the negative steady as it's magnified and projected onto paper to make a print.
11. Measuring beaker
Chemical-to-water ratio in the trays determines development time.

PRINTING BLACK-AND-WHITE PHOTOGRAPHS is like tango dancing, says Brian Young. Each step of the film development has a rhythm. Or it's like making a flan: Each chemical mix is precise in measurement and temperature. Young began printing in black and white in the 1980s and got hooked on "the ability to control everything," compared with color photography. Today, in his Connecticut studio, it may take two hours to turn a piece of film into a print. "It's not about being quick, easy, or convenient," says Young. "It's about being difficult, slow, and something you have to learn." —NINA STROCHLIC

INNOVATOR

OSCAR NILSSON

BY **KRISTIN ROMEY** PHOTOGRAPH BY **AXEL ÖBERG**

From archaeologists' finds, he reconstructs lifelike human faces.

Oscar Nilsson has the gift of being able to put a face (but not necessarily a name) to roughly a hundred once anonymous individuals whose remains have been excavated by his fellow archaeologists. The Swedish reconstruction expert relies on his deep knowledge of facial anatomy as well as his skills as a sculptor to bring to life, for example, the regal visage of a 1,200-year-old Peruvian noblewoman or the surly adolescence of a 9,000-year-old Greek teenager.

Nilsson begins with a 3D-printed copy of an original skull and crafts facial features by hand, guided by bone structure and relying on scientific data sets to estimate the thickness of muscle and flesh in different areas of the face. Once reconstruction reaches what Nilsson calls the mannequin stage, his artistic chops kick in to "get life into the face" with scientific accuracy.

The new and rapidly developing field of ancient DNA has been a "game changer" for facial reconstruction, Nilsson says. When he entered the field 20 years ago, determining the skin, hair, and eye color of his subjects was a guessing game. But in the past decade, improvements in extracting and analyzing DNA gave Nilsson more data about populations' travels and origins, so he could give, say, an early inhabitant of Mesolithic Britain the appropriate dark skin and eyes. "It's fantastic that we can get that detail," he says, "to make it really relevant." ▯

MAKING PORCUPINE BABIES TAKES ALL MANNER OF MOVES

PHOTOGRAPH BY
JOEL SARTORE

AS AN OBSERVER of the North American porcupine for more than 30 years, Uldis Roze has no idea how many times he has heard this joke.

How do porcupines reproduce? Very carefully.

That answer is "correct, but not very enlightening," says Roze, a professor emeritus of biology at New York's Queens College. In reality, the mating ritual of the quill-covered *Erethizon dorsatum* is quite elaborate, protracted, and ... damp.

The species' annual mating season is in early fall. In her chosen tree, the female signals she's about ready to breed by secreting an odoriferous substance. Males drawn by the smell fight each other in the tree branches and on the ground below her. The one not knocked out wins mating rights—but the seduction's not done.

To induce estrus in the female, the male squirts her with urine, a few drops at a time. The urine is "propelled at such high velocity," Roze says, "that even if a male and female are sitting on separate branches in a tree, his urine can reach her." The male keeps it up—"repeated salvos over many hours," Roze says—until the female is in the mood. Typically, the two then descend the tree to breed.

Quills could make mounting the female a prickly proposition. But when she's ready, the female curves her tail over her spiky back so her tail's quill-free underside is facing up, Roze says. The male then can rest his paws on that surface while doing the deed.

Approximately seven months later, the female will give birth—in this species, usually a single offspring. Known as a porcupette, the baby is born with all its quills but also wrapped in the amniotic sac that smooths the little one's arrival. **—PATRICIA EDMONDS**

THIS FEMALE NORTH AMERICAN PORCUPINE WAS PHOTOGRAPHED AT THE GREAT PLAINS ZOO, SIOUX FALLS, SOUTH DAKOTA.

The Climb of His Life

WHEN THE WORLD'S DEEPEST KNOWN CAVE SUDDENLY FILLS WITH WATER, A PHOTOGRAPHER TRAVELING WITH ELITE RUSSIAN EXPLORERS MUST SCRAMBLE TO SURVIVE.

STORY AND PHOTOGRAPHS BY
ROBBIE SHONE

I HAD JUST BEGUN BREAKFAST on September 16, 2018, when we received the radio call. A flood pulse was coming. It would reach us in 30 minutes.

Photo assistant Jeff Wade and I were camped some 6,890 feet below ground with members of the Perovo-Speleo caving team, an elite group of Russian cavers who are pushing the boundaries of exploration. We'd been underground for 11 days in the deepest known cave in the world: the Veryovkina system in Abkhazia, a self-declared republic in the country of Georgia. Two days earlier I'd taken the photograph you see above of expedition leader Pavel Demidov climbing out of the terminal sump, the cave's deepest point.

Flood pulses—when a sudden accumulation of water bursts through any opening it can find—happen often in caves, and at first we weren't concerned. (We learned later that there'd been a week of rain above ground.) Our eight-person tent was pitched in a side passage halfway up a chasm. We thought we'd be out of the way of the main flow of water. We continued with our breakfast.

I will never forget the sound, as if a freight train were about to crash through camp. It got louder and louder. Everyone stood open-mouthed staring upward, wondering what was going to appear out of the darkness. Then an enormous torrent cascaded past our camp and plummeted deeper into

18+

WHAT IS AVAXHOME?

AVAXHOME-

the biggest Internet portal, providing you various content: brand new books, trending movies, fresh magazines, hot games, recent software, latest music releases.

Unlimited satisfaction one low price
Cheap constant access to piping hot media
Protect your downloadings from Big brother
Safer, than torrent-trackers

18 years of seamless operation and our users' satisfaction

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Brand new content
One site

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AvaxHome - Your End Place

We have everything for all of your needs. Just open https://avxlive.icu

the chasm. We decided to wait and see how it would develop. Sometimes flood pulses pass quickly.

After a couple of hours, Petr Lyubimov, one of the Russian cavers, noticed gurgling coming from a deep hole on the edge of camp where we'd been spitting our toothpaste. Pavel and Andrey Shuvalov left to check the water levels deeper in the cave system.

Shortly after they'd gone, Petr inspected the toothpaste hole again. When he turned around, his white face said it all. The hole was full of water. The water was rising. We had to act fast. In camp we wore only base layers, fleecy onesies to keep us warm. Over them we hurriedly put on latex dry suits, Cordura oversuits, harnesses, and climbing gear. The others were used to this gear and were quick. But in the panic, Jeff and I had to help each other seal our dry suits. My equipment was spread all over the ground. I grabbed the memory cards from the camera, put them in a Ziploc bag and into my chest pocket. I left the rest.

Every single hole around camp was bubbling.

"We're leaving right now," I said to Jeff.

We hurried across a traverse that had skirted a 50-foot drop. That drop was now a lake, and we were only three feet above the water. I turned to Petr and

The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.

Cavers descend into a grotto at the lowest levels of the Veryovkina system. During the flood, water was up to the ceiling.

shouted, "Come on, Petr, we have to evacuate camp."

He said he would wait for Pavel and Andrey to come back. I thought I would never see him again.

Using ascenders, we climbed ropes dangling through shafts that had become raging waterfalls. I don't know whether I was more scared of the rising water below or the torrent of water pummeling us from above. To breathe, we kept our heads down and tucked in our chins, creating a small air space under the front of the helmet. It took every ounce of effort to move an inch at a time, and we had nearly 600 vertical feet to go.

I was in the lead. If I couldn't get past an obstacle, everyone behind me would be stuck with no way out while the water rose. I panicked. I climbed so quickly that I lost sight of Jeff. I honestly thought that he and the others were dead. Then I heard a very angry voice behind me. Jeff was yelling at me to slow down. I was so relieved to hear him. Finally, we reached a temporary bivouac in a side passage where we could wait safely, out of the water and cold wind.

The first of the other cavers appeared. We asked him if he'd seen anyone else. He said no. We assumed the rest were dead, though we didn't say it. We continued on to the next camp and waited.

Then others started to appear. They'd managed to grab sleeping bags and a stove. Everyone had survived, though Petr had injured his knee badly.

We couldn't climb further because the next waterfall led to a narrow horizontal passage that would be completely flooded. We waited 16 hours, trapped between the floodwaters below and an impassable waterfall above.

The Russian cavers, feeling relatively safe, were soon laughing among themselves in the tent. Jeff and I paced outside, watching to see if the waters would rise again. We didn't take off our harnesses or any clothes; we wanted to be ready if anything happened.

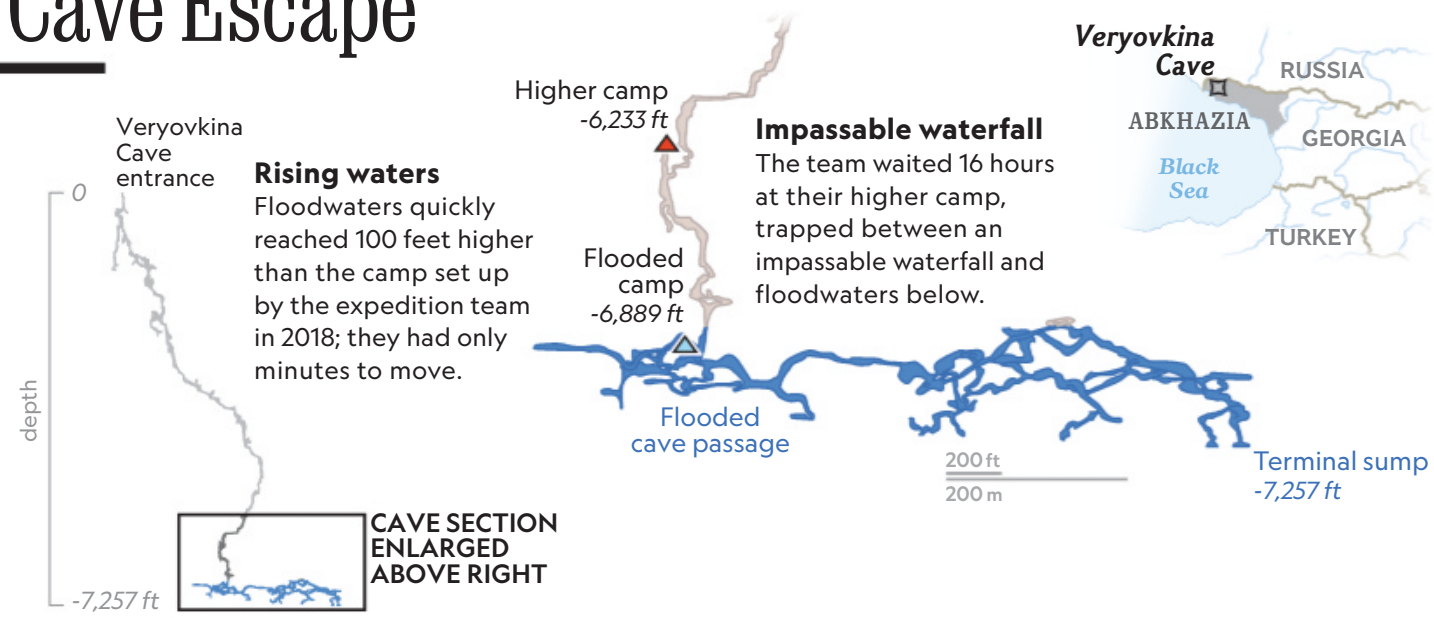
But finally, the flood died down. Jeff and I escorted the injured Petr to the next camp. The others went back down to try to salvage what they could from below. They came back with my camera and tripod but said that one of my waterproof containers was wedged into the cave roof.

It took us four days to get to the surface. We each reached the top alone. My senses are usually heightened after I emerge from a caving trip: Smells are stronger, colors more vivid, and sounds clearer. This time, everything seemed strangely dampened. I felt like a ghost living out my life as it would have been. But I have also never felt such relief. I remember a blood-red moon sinking on the horizon of the Black Sea.

One year later, Pavel and team member Kostia Zverev arrived at my home in Innsbruck, Austria. They put two bottles of vodka in the freezer and asked me to close my eyes. When I opened them, there on my kitchen table was some of the equipment I had left behind. □

Robbie Shone has been photographing and exploring caves for 20 years. His most recent story for the magazine was the March 2017 feature "Into the Deep," about the Dark Star cave system in Uzbekistan.

Cave Escape



DAVID L. LAMBERT, NGM STAFF. SOURCE: PAVEL DEMIDOV, PEROVO-SPELEO

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India's Water Needs..... P. 74
Women's Suffrage..... P. 96
Uganda Chimps..... P. 124

FEATURES

PHOTO ILLUSTRATION OF SUFFRAGIST ALICE PAUL BY JOHANNA GOODMAN.
IMAGES: LIBRARY OF CONGRESS; CELESTE SLOMAN (ERA BUTTONS)

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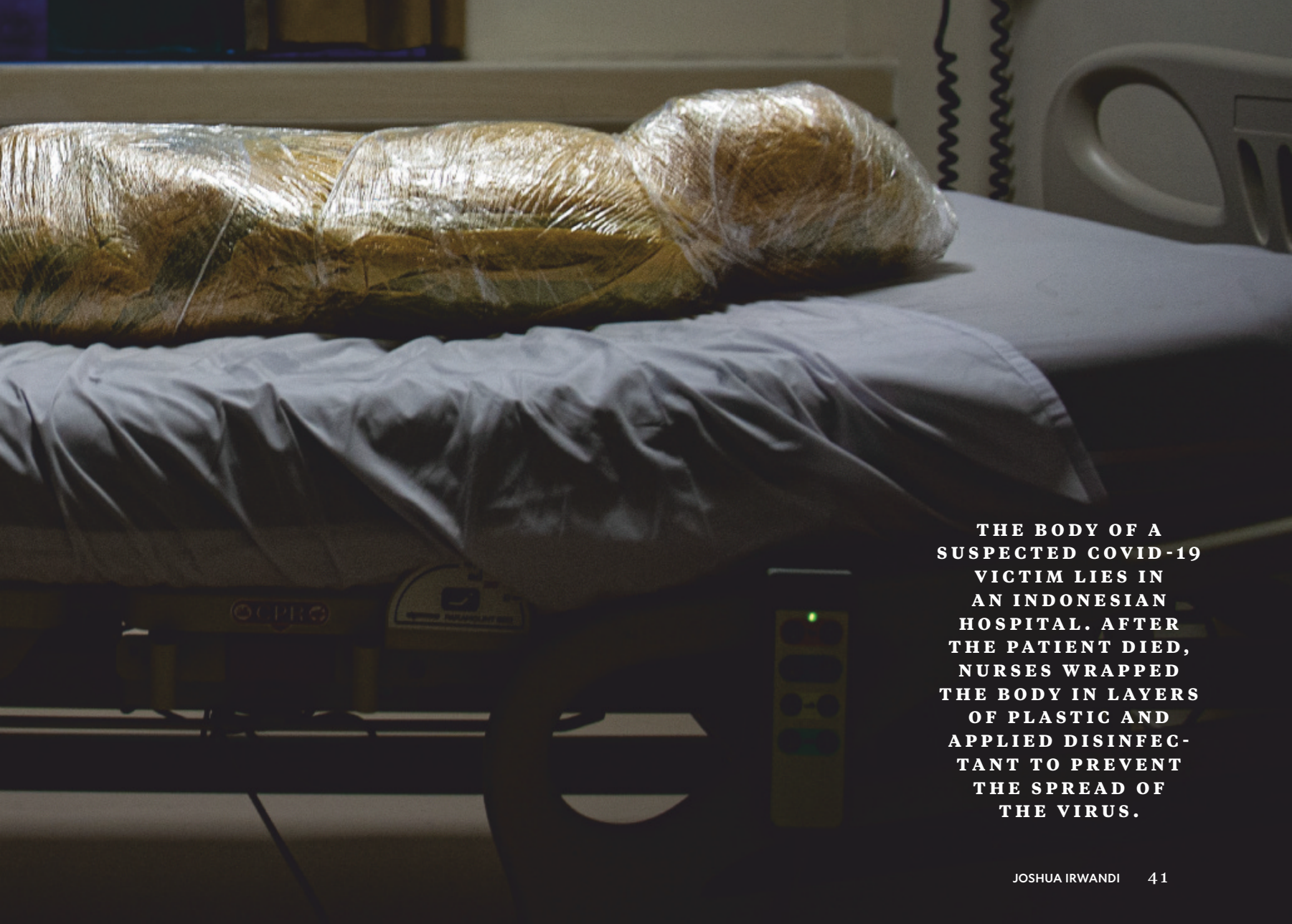
ALICE PAUL RECRUITED ACTIVISTS TO STAND SILENTLY IN FRONT OF THE WHITE HOUSE IN 1917, MANY HOLDING SIGNS THAT READ, 'MR. PRESIDENT WHAT WILL YOU DO FOR WOMAN SUFFRAGE?'

How pandemics

Will we remember the lessons we have

change us

learned after the danger has passed?



THE BODY OF A SUSPECTED COVID-19 VICTIM LIES IN AN INDONESIAN HOSPITAL. AFTER THE PATIENT DIED, NURSES WRAPPED THE BODY IN LAYERS OF PLASTIC AND APPLIED DISINFECTANT TO PREVENT THE SPREAD OF THE VIRUS.

What history

BONES FROM 30,000 PLAGUE VICTIMS WHO DIED DURING A 14TH-CENTURY OUTBREAK ADORN THE SEDLEC OSSUARY IN THE CZECH REPUBLIC.

CHARLIE HAMILTON JAMES

has taught us

What it means

AUTOWORKERS EAT LUNCH IN A FACTORY IN WUHAN, CHINA. THEY MUST WEAR MASKS, UNDERGO TEMPERATURE CHECKS, AND MAINTAIN SAFE DISTANCES.

STR/AFP VIA GETTY IMAGES

for us today

By Richard Conniff

On a Sunday early in March, as the COVID-19 outbreak was racing across the planet, the U.S. Coast Guard cutter *Pike* pitched and rolled en route to the cruise ship *Grand Princess*, waiting 14 miles off the coast of California. The cutter was delivering a medical disaster team to separate the sick from the seemingly healthy among the 3,500 people aboard and prepare to bring them ashore. On the *Pike*, Michael Callahan, an infectious disease specialist with decades of experience in 'hot zones' everywhere, waited with his team, he says, 'unheroically' vomiting.

Passengers gather on the decks of the Grand Princess *as it prepares to dock in Oakland, California, on March 9. Authorities had the ship circle at sea for days; eventually more than 100 passengers and crew tested positive for COVID-19. After docking, many foreign crew members remained aboard, unable to return home because of travel bans.*

GABRIELLE LURIE, *SAN FRANCISCO CHRONICLE* VIA GETTY IMAGES

Michael Callahan

Shortly before sunset, the *Pike* approached a tender lowered from the *Grand Princess*. Callahan, age 57, and his team, still seasick, were now also half-deafened and blinded in full biocontainment gear. One by one, they made the leap first to the tender, and then, as the boat banged against the hull of the 188-foot-tall cruise ship, they leaped again onto a ladder and climbed up the hull to begin their work.

The entire world at that moment was also taking a leap into the unknown. Or rather, into the forgotten. Epidemics always have afflicted humans, and pandemics since we first sprawled across the globe. They have taught us important lessons—if only we could manage to remember them in our exhaustion and relief after danger has passed us by. New pandemics such as COVID-19 have a way of reminding us how easy it is for us to infect one another, especially those we love. How fear of contagion forces us apart. How devastating isolation can be, and yet how the sick often must die miserably and alone. Above all, the new pandemic has reminded us how much we've always depended on a small, brave band of people like Callahan—we'll come back to him—who risk their lives fighting diseases.

These people have often been too flawed, too human, to fit the traditional mold of hero. In past pandemics, they have tended to be individuals willing to disregard conventional thinking, to learn from small, seemingly insignificant clues, or to listen to unexpected voices. And they have been willing to recognize that what happened over there, in some dismal neighborhood or some forgotten corner of the world, could easily happen here too. To understand these people who help end pandemics, the best place to start is with one of the worst diseases in human history.

ILLUSTRATIONS BY JOE MCKENDRY

Finding a remedy

Cotton Mather

At a lecture in Boston early in 1721, Cotton Mather, the hellfire Puritan minister, announced the coming of 'the destroying angel,' a terrifying disease bearing down on the city. England was already under siege.

The New World had felt its dreadful effects before, passing through in unpredictable waves over 200 years, inflicting panic and misery on the colonists and wiping out entire Native American societies. But it had been 19 years since Boston's last epidemic, time enough to raise a fresh generation of victims.

When the first light-red spots appeared, you could hope it might be just measles. But then the spots turned into bumps, filled with fluid, and rose up like volcanic islands on the skin. Hundreds of them could clot the eyes, the air passages, the entire body, to make even breathing an agony. The pustules gave off the stench of rotting flesh. Survivors were often blinded, crippled, or badly disfigured. (The doctor tending one sick British woman was instructed, "Preserve her beauty, or take her life.") That April, smallpox slipped quietly into Boston Harbor.

At first, people ignored the outbreak, much as has happened in our own time. But starting in 1721, smallpox taught the Western world a powerful new lesson: Humans can prevent pandemic diseases. We can hem them in and, if we have the will, sometimes even eradicate them. Three unlikely heroes took up the fight that year in Boston. They included the African-born slave Onesimus—a biblical name Mather had put on him—and a physician and surgical innovator named Zabdiel Boylston. But the unlikeliest of them was Mather himself, a troubled character, vain, emotionally unstable, and still widely disliked as a dark force behind the Salem witch trials 29 years earlier.

Now, though, it was as if Mather had been preparing all his life for this moment, and for redemption. He had been a keen student of science and medicine from childhood, and no doubt it also became personal: Two wives and 13 of his 15 children would die before him, many from infectious disease. So he read British science journals and studied Native American

A DERMATOLOGY PROFESSOR IN OHIO DOCUMENTED A SURVIVOR'S SMALL-POX SCARS IN 1902. A VACCINE HAD EXISTED FOR 100 YEARS, BUT THE U.S. STILL ENDURED OUTBREAKS UNTIL 1949.

DITTRICK MEDICAL HISTORY CENTER,
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medicines. And he paid attention when his "servant" Onesimus, "a pretty Intelligent Fellow," told him about a method of preventing smallpox in Africa and showed him the resulting scars. Details of this method were also circulating in England, based on reports from Turkey.

As the outbreak was beginning to spread, Mather alerted Boston's physicians to "a Wonderful Practice lately used in several Parts of the World" to stop it. The technique was to take a patient with smallpox and puncture one of the ripe pustules to draw off pus, or "variolous matter." A portion of this material then went into an incision in the skin of someone who was still perfectly healthy. The promise of "variolation," or inoculation, was that it would produce immunity, after what would probably be only a mild case of one of the deadliest diseases on Earth.

Mather found corroborating accounts and scars from the procedure among "a Considerable Number" of other African-born Bostonians. Boston's medical community recoiled. But Zabdiel Boylston knew the terror of smallpox from having nearly died of it 19 years earlier, and he worried that his medical practice put his eight children "daily in danger." On June 26, having considered the evidence, he performed his first variolations, on his six-year-old son and two family slaves. The result was "a kind and favourable Small-Pox," and he began to inoculate patients seeking protection from the full-blown disease.

Some city residents considered the treatment as terrifying at first as the disease itself. They worried that variolated patients who hadn't fully recovered were still contagious. Doctors objected that the practice flew in the face of medical orthodoxy, which had held for 2,000 years that disease resulted from an imbalance in four bodily "humors," often brought on by foul odors and ill-defined "miasmas," or bad air.

Starting in 1721, smallpox taught the Western world a powerful new lesson: Humans can prevent pandemic diseases. We can hem them in and, if we have the will, sometimes even eradicate them.

Tradesmen and laborers couldn't afford to protect their families because of the high cost of inoculation and the attendant medical care before and after. Terror and class resentment, together with the lingering shadow of the witch trials, helped make Mather a target. One night a firebomb came flying through a bedroom window of his house. By chance, the fuse fell off and the bomb landed with a harmless thud. Tied to it was a note: "COTTON MATHER, You Dog, Dam you: I'll inoculate you with this, with a Pox to you."

By the time the epidemic finally ended, almost 6,000 residents, more than half of Boston, had come down with smallpox and 844, about 15 percent, had died. On the other hand, just 2 percent of those who had undergone variolation died. Improvements soon drove that to less than half a percent, and variolation became standard practice. When another smallpox epidemic hit Boston in 1792, the response had completely reversed: About 9,200 local residents were inoculated, and only 232 of them suffered natural smallpox.

None of the three men who introduced variolation to North America won much honor by it. Onesimus disappeared from the record after purchasing his freedom, and the African contribution was swept out of sight. Zabdiel Boylston was also mostly forgotten. Streets, buildings, and a nearby town named Boylston actually honor his grandnephew, a wealthy merchant. Cotton Mather, finally, did not win redemption in Boston hearts. But he continued to think on medical matters, eventually writing about the true cause of all epidemics: In the proper conditions, tiny organisms, which were then just beginning to be seen by microscope, "soon multiply prodigiously; and may have a greater Share in producing many of our Diseases than is

An illustration in the Japanese manuscript The Essentials of Smallpox, *published circa 1720, depicts the disease's telltale rash. The origins of the smallpox virus are unknown, but it is believed to have afflicted Egyptians more than 3,000 years ago. After a global vaccination campaign, the World Health Organization finally declared it eradicated in 1980.*

WELLCOME COLLECTION, ATTRIBUTION 4.0 INTERNATIONAL

commonly imagined." But his otherwise eccentric manuscript went unpublished. It would take scientists another 150 years to recognize the critical role of microbes as the agents of infectious disease.

The push for variolation in North America and Europe produced one other unexpected effect. In 1757, in a small town in the south of England, a "fine ruddy boy" of eight underwent variolation. It was a miserable experience, because doctors bound by tradition demanded a preparatory regimen of bleeding and purging. When the boy became a country doctor himself, "a vague opinion prevailed" among the dairies, he wrote, that a livestock disease called cowpox might be "a preventive of the Small Pox." The possibility of a better way made a powerful impression on Edward Jenner. But for decades, no one put this rumored treatment into practice, until finally Jenner himself saw his chance.

On May 14, 1796, he performed what looked like variolation on another eight-year-old boy, named James Phipps, but using material from a young woman infected with cowpox. It was the beginning of modern vaccination, a term coined from the Latin *vacca,* for cow. The first anti-vaxxers immediately rose up in outraged protest. They feared, among other things, that people could develop cow-like tendencies, catch animal diseases, or even sprout horns. But vaccination proved so much safer and more effective than variolation that it soon spread across the Earth.

Smallpox continued to kill people, an estimated 300 million in the 20th century alone. In May 1980 the World Health Organization declared smallpox eradicated thanks to a determined global vaccination campaign. By then, Jenner's vaccine had become the model for a host of others. They drove so many infectious diseases from our lives that for a brief, happy interlude, it seemed possible that such a thing as a pandemic could never happen again.

An Empire Subdues a Pandemic

Colonizers from Europe brought Old World diseases with them to the Americas, devastating indigenous populations. Almost 300 years later, the Spanish king ordered an ambitious mission to fight one of the deadliest: smallpox.

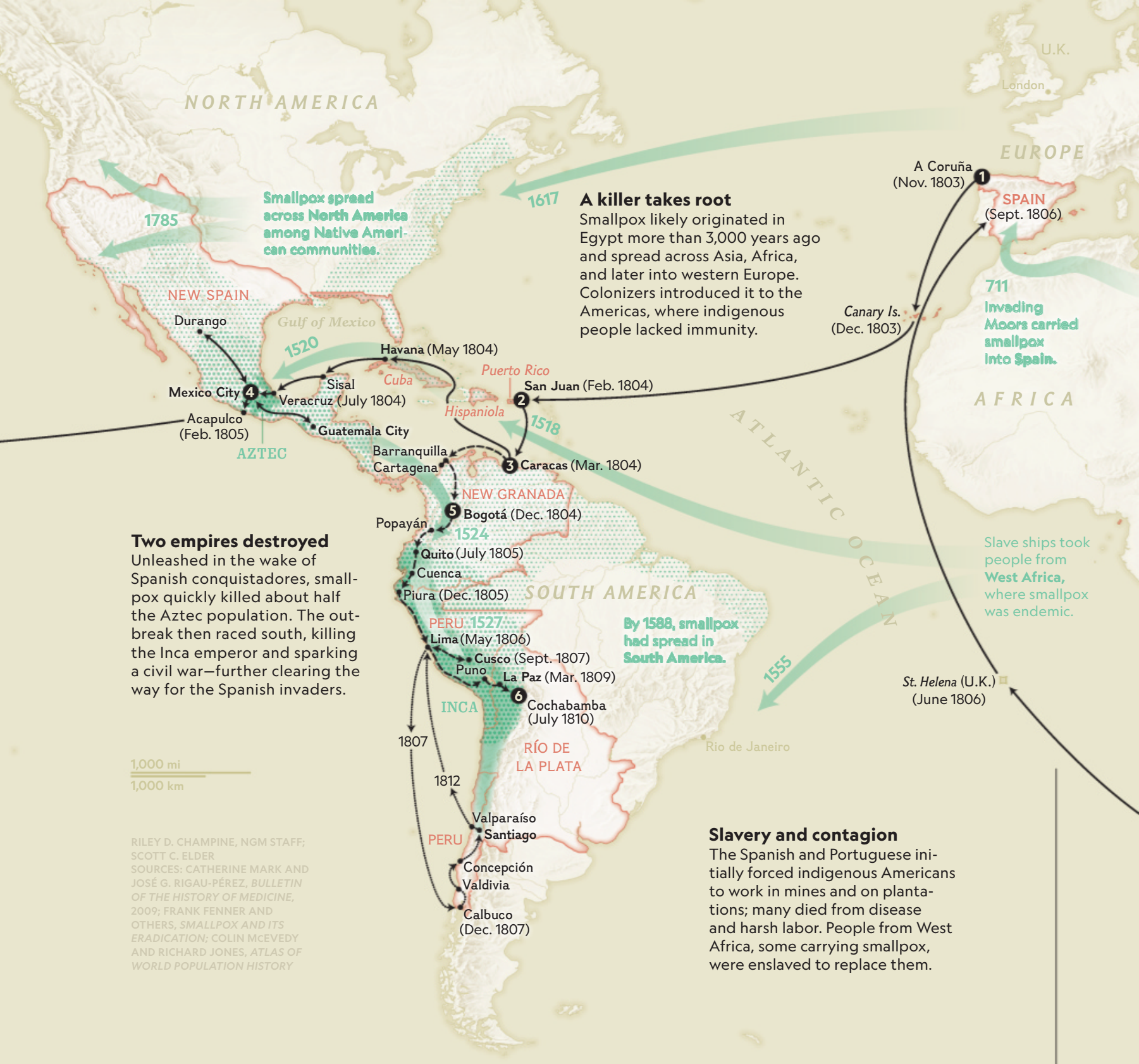
ONCE EDWARD JENNER SHOWED in 1796 that injection with less virulent cowpox could protect people against deadly smallpox, he quickly became, in his words, "vaccine clerk to the world." Other physicians in England and elsewhere soon joined the cause. But Spain's King Carlos IV went much further, ordering an audacious maritime expedition to disseminate vaccination throughout the Spanish Empire.

The Royal Philanthropic Vaccine Expedition would become the first global public health initiative. The goal was to establish regional boards throughout the empire to maintain a supply of vaccine and oversee its use, train vaccinators, and administer the vaccine at no cost. A Guatemalan physician with years of experience inoculating people to prevent smallpox helped plan the expedition. He advocated using indigenous languages, working with trusted community leaders, and treating patients humanely.

The expedition, under the command of Francisco Xavier de Balmis, sailed in the corvette *María Pita* in November 1803. To address the challenge of transporting live cowpox across the Atlantic, the vessel carried 22 young boys from orphanages. ❶ The medical team vaccinated a pair of the boys, later used matter from their pustules to inject another pair, and so on in succession during the 10-week voyage, ensuring a supply of live vaccine upon arrival in Puerto Rico. ❷

It turned out that Puerto Rico already had vaccine delivered by other means. Venezuela, which had not yet been so fortunate, celebrated its arrival with fireworks, concerts, and a Mass of thanksgiving. ❸ The main expedition sailed on to introduce vaccine to Cuba, Mexico, and Central America. The Spanish foundlings were adopted by Mexican families, and 26 Mexican boys replaced them for the Pacific crossing. ❹

The expedition's surgeon, José Salvany, headed south on another leg of the humanitarian mission, entailing years of discomfort and

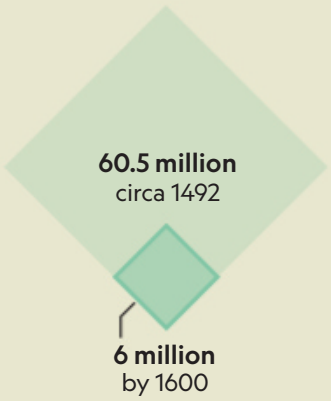


danger in the campaign against smallpox. His contingent carried the vaccine overland on a 2,500-mile route down the Pacific coast from present-day Colombia to Ecuador, Peru, and Bolivia. 5 Salvany and his teams vaccinated more than 200,000 people in South America. He died in Bolivia in 1810, at just 36, of an apparent heart condition. 6

The main expedition continued to the Philippines, with Balmis branching off to China. 7 The round-the-world voyage ended in 1806 with his return to Spain. But Balmis remained devoted to the cause, working to spread vaccination overseas until 1813.

Modern scholars sometimes characterize such medical initiatives as opportunistic devices for advancing colonial enterprises and controlling indigenous populations. But everyone at the time, from the king's own family on down, understood the deep terror of smallpox as an inevitable fate. The medical staff, devoting their lives to the cause of vaccination, surely acted out of a genuine commitment to defeating this terrible disease.

Estimated indigenous population in the Americas



The native population of the Americas declined by an estimated 90 percent in the first century after Europeans arrived. Smallpox was a leading cause of death.

IN FOCUS

Plague

The third pandemic of the plague began in China in 1855 and reached every continent but Antarctica between 1894 and 1900. The bacteria hit Madagascar in 1898 and remains today.

During the 1990s researchers discovered a new drug-resistant strain of the plague in Madagascar.

A sanitary team puts a plague victim in a coffin during an outbreak in Madagascar around 1935. Some doctors were concerned that the Malagasy tradition of famadihana, *or reburial, helped spread the disease. Practiced mostly in the island's central highlands, the ritual requires mourners to exhume, clean, re-shroud, and dance with corpses, before reinterring them. Despite governmental efforts to discourage famadihana, some new cases of plague in Madagascar have been associated with reburial gatherings.*

INSTITUT PASTEUR

DATA SHEET

Scale of Suffering

Disease has spelled suffering, death, and even the demise of entire civilizations. Some pathogens did their damage swiftly, others moved in deadly waves over decades. Here are some of the worst outbreaks of all time—those that changed the course of history.

Epidemic
Excessive number of cases for a geographical area

Pandemic
Epidemic spreads to multiple regions or countries

Plague pandemic
Global disease caused by *Yersinia pestis* bacteria

Death toll *(millions of people)*

Virus, bacterium *(if known)*

Animal source *(if any)*

Plague of Justinian
541-588, Byzantine Empire

Flea-ridden rats on grain ships are thought to have brought the plague to Constantinople. It then spread throughout the Mediterranean world. Present until 750, at its peak it is thought to have killed thousands of people each day.

50 M
Yersinia pestis
Rats Fleas

Black Death
1347-1351, global

One of the most devastating outbreaks in human history, this plague killed 30 to 50 percent of the European population. Written accounts of the time spoke of villages, castles, and towns with only a few people left alive.

50 M
Yersinia pestis
Fleas Lice

Cocoliztli 1
1545-48, Mexico

The little-understood disease killed up to 80 percent of the native population. Symptoms included high fever, headaches, and bleeding from the eyes, nose, and mouth.

15 M

Antonine Plague
165-180, Roman Empire

What historians believe may have been smallpox killed up to 2,000 of Rome's citizens every day. It had a devastating 25 percent mortality rate.

5 M

Smallpox
1519-1520, Mexico

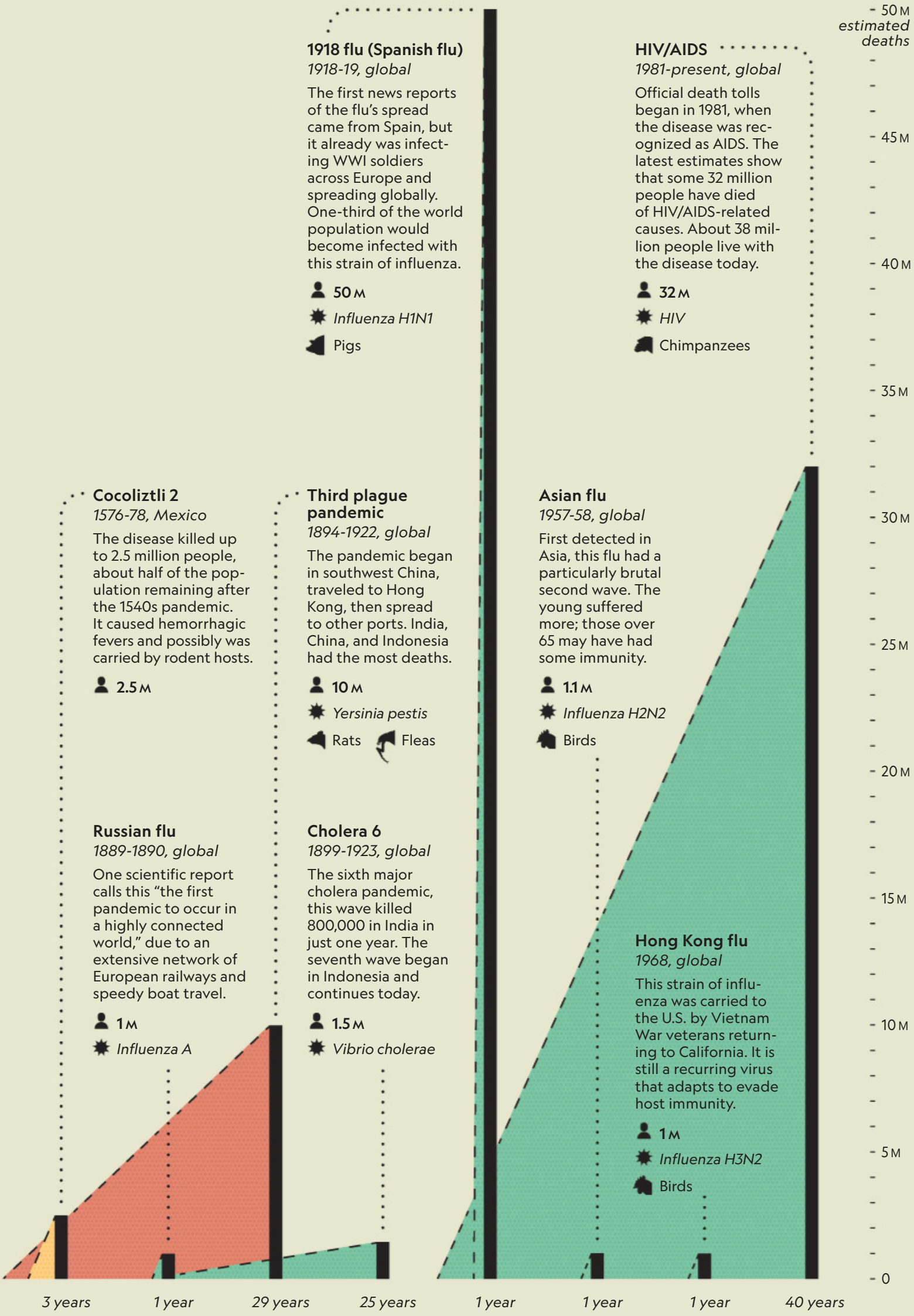
The arrival of Spanish conquistadores in what is now Mexico spelled the end of the Aztec civilization. It devolved into strife and chaos as the disease spread.

8 M
Variola

Outbreaks in chronological order ▶

Approximate duration of outbreak ▶ 0 | 16 years | 48 years | 5 years | 2 years | 4 years

SCHOLARLY ESTIMATES OF DEATH TOLLS VARY.


50 M
estimated deaths
45 M
40 M
35 M
30 M
25 M
20 M
15 M
10 M
5 M
0
1918 flu (Spanish flu)
1918-19, global
The first news reports of the flu's spread came from Spain, but it already was infecting WWI soldiers across Europe and spreading globally. One-third of the world population would become infected with this strain of influenza.
50 M
Influenza H1N1
Pigs
HIV/AIDS
1981-present, global
Official death tolls began in 1981, when the disease was recognized as AIDS. The latest estimates show that some 32 million people have died of HIV/AIDS-related causes. About 38 million people live with the disease today.
32 M
HIV
Chimpanzees
Cocoliztli 2
1576-78, Mexico
The disease killed up to 2.5 million people, about half of the population remaining after the 1540s pandemic. It caused hemorrhagic fevers and possibly was carried by rodent hosts.
2.5 M
Third plague pandemic
1894-1922, global
The pandemic began in southwest China, traveled to Hong Kong, then spread to other ports. India, China, and Indonesia had the most deaths.
10 M
Yersinia pestis
Rats
Fleas
Asian flu
1957-58, global
First detected in Asia, this flu had a particularly brutal second wave. The young suffered more; those over 65 may have had some immunity.
1.1 M
Influenza H2N2
Birds
Russian flu
1889-1890, global
One scientific report calls this "the first pandemic to occur in a highly connected world," due to an extensive network of European railways and speedy boat travel.
1 M
Influenza A
Cholera 6
1899-1923, global
The sixth major cholera pandemic, this wave killed 800,000 in India in just one year. The seventh wave began in Indonesia and continues today.
1.5 M
Vibrio cholerae
Hong Kong flu
1968, global
This strain of influenza was carried to the U.S. by Vietnam War veterans returning to California. It is still a recurring virus that adapts to evade host immunity.
1 M
Influenza H3N2
Birds
3 years
1 year
29 years
25 years
1 year
1 year
1 year
40 years

ALBERTO LUCAS LÓPEZ, NGM STAFF; AVIVA HOPE RUTKIN
SOURCES: GRAHAM MOONEY, JOHNS HOPKINS UNIVERSITY; CHRISTIAN MCMILLEN, UNIVERSITY OF VIRGINIA; WHO; CDC

Cholera changes cities

Edwin Chadwick

People were willing to accept the next great lesson in ending pandemics only because of a disease that was among the most frightening they had ever experienced. When this scourge broke out in 1817 in the city of Jessore, now part of Bangladesh, its new virulence shocked people even there, though they knew its terrors from past outbreaks.

"So unforeseen and appalling was the attack," wrote a district official, that astonished residents "fled in crowds to the country as the only means of escaping impending death." In just a few weeks, 10,000 people died in this one district.

A booming commercial and colonial trade carried the new outbreak overland and across oceans and made it pandemic. Newspaper readers could follow reports from the front lines as the dreaded disease crept toward them. It wasn't just that it killed half its victims and did so with appalling speed. A special horror attended the way they died, with a person who was in the prime of life one moment seeming, in the next, to liquefy and flow out in uncontrollable vomiting and diarrhea. Intense thirst followed. Spasms and cramps wrenched the muscles. Breathing became a desperate, gasping "air hunger." Victims died with their minds seemingly intact, staring, aghast, the watery liquid still being wrung from their guts.

When people debated the cause of this new menace, miasmas and foul odors were the usual suspects. Almost all the early sanitary reformers focused obsessively on smells, partly because they were everywhere—the acrid odors of factories, the pigsties adjacent to homes, the tonnage of droppings from horses and livestock, the tanneries, the shallow graves of the dead, and of course human excrement everywhere. For the sanitary movement, "putrid exhalations" were the cause of disease.

In the 19th century, as people left the farm and lined up for factory jobs in the city, humanity still badly needed lessons in how to live together without dying. Practices that had seemed harmless on the farm, like the lack of organized sewage disposal, proved fatal in cities. Families huddling one atop another in squalid slums circulated and recirculated typhoid fever, dysentery, tuberculosis, cholera, and other infectious diseases.

The great teacher of sanitary reform was a

The bodies of cholera victims in July 1994 lie outside a clinic in what is now the Democratic Republic of the Congo. In less than a week, almost a million refugees fleeing Rwanda in the wake of the genocide crossed the border near Goma. Crowds overwhelmed refugee camps and their sanitation services, allowing the disease to spread and kill 50,000 people.

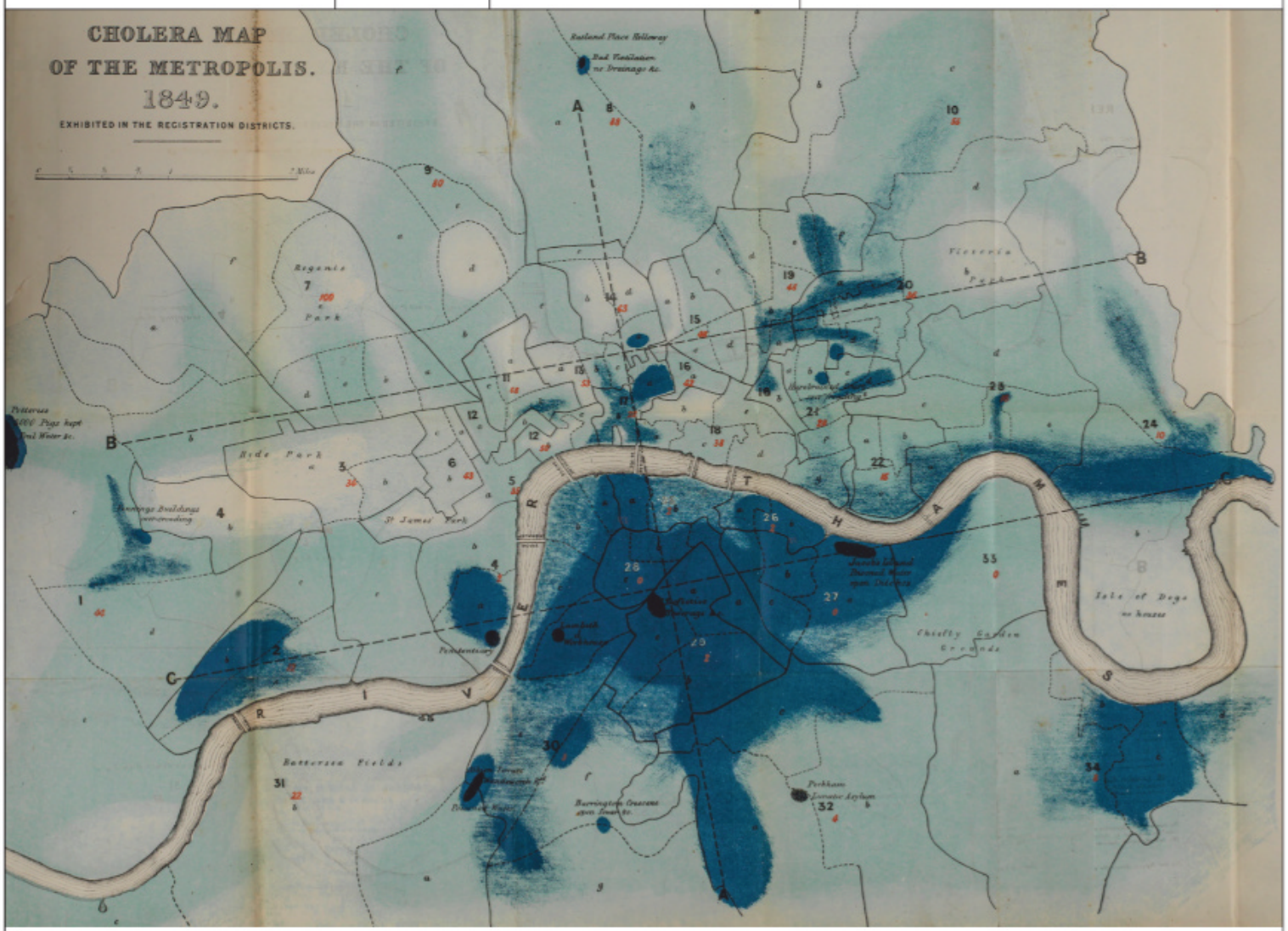
TEUN VOETEN, PANOS PICTURES

British civil servant named Edwin Chadwick, a Dickensian bureaucrat, tall, round-faced, hair smeared in hanks across his balding scalp, peering out from heavy-lidded eyes in judgment, if not disdain. He was "a really outstanding specimen of bore," according to one biographer, "in an age when the species flourished." But he also made a reputation for mastering the facts of any problem he studied and for bringing prodigious energy to the solution.

In 1842 Chadwick wrote an unlikely best seller, published by the British government, now known as *The Sanitary Report*. Based on accounts from around Britain, it described in unblinking detail an urban working-class world that must have seemed as foreign as Jessore to most educated readers of the era. Chadwick led them into cellars three feet deep in human waste from overflowing cesspools, and houses where "every article of food and drink must be covered" to avoid "the strong taste of the dunghill" carried in by houseflies. He described a town where "the filth" of a jail holding 65 prisoners "is floated down the public streets every second or third day," joined by blood from the local slaughterhouse.

Chadwick was a believer in "filth theory" and the deadly power of stenches. Luckily, his detailed recommendations also happened to work against the real causes of disease.

The visceral horror of *The Sanitary Report* roused reluctant politicians to the need to do something. In 1848 the British government established one of the world's first national public health authorities, with Chadwick in charge. The following year a cholera outbreak unexpectedly cracked the whip on behalf of sanitary reform. Chadwick soon launched a nationwide campaign pushing cities and towns to build centralized public systems to supply clean water to homes, together with properly designed sewerage to carry away wastes. It was a massively expensive undertaking but produced dramatic



In 1849 Great Britain's new General Board of Health published a "Cholera Map of the Metropolis," showing the distribution of the disease in London. The map depicts parts of the city with the highest death rates in dark blue and labels areas with "Poisoned Water," "open Sewer," and "over-crowding"—all factors in spreading the infection.

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improvements in health and life span. Other nations followed, and for the first time cities began to become truly livable.

None of this is ancient history. The shift from farm to city began in the industrial revolution, but the human species became predominantly urban for the first time only in 2008. The United Nations estimates that by mid-century, 68 percent of humans will live in urban areas. That means many people once again need to learn that the move from the farm to the city changes how they live. They also need systems that allow them to make that change safely. But many developing nations don't have the money to pay for sanitary reform.

Today 2.1 billion people lack access to a safe water supply at home, and 4.5 billion lack safely managed sanitation. The absence of both was the main factor sustaining the recent cholera epidemic in Haiti, which sickened at least 800,000 people and killed 10,000 there over nine years. Other victims live in the surging megacities of Asia, Africa, and Latin America. It is as common in large parts of these cities for drinking water to be contaminated with fecal matter as it was for London in 1848, and access to basic medical care is almost nonexistent. So they still suffer old diseases, such as pneumonia, childhood diarrhea, and tuberculosis, which alone killed 1.5 million people in 2018, and also relatively new ones, such as HIV/AIDS, which still kills 770,000 people a year. What's even more ominous, many of these gigantic cities are close to areas of high wildlife diversity—with an abundant supply of potential new pathogens capable of spilling over to humans. It's a recipe for breeding new pandemics. Perhaps the ravages of COVID-19, like those of cholera in Chadwick's London, will become the whip that drives governments to bring sanitary reform to every urban community, as one measure to keep those pandemics from happening.

John Pringle

Appalled by conditions he observed in an army hospital, a British doctor recognized the importance of good hygiene and instituted reforms that have saved countless lives on and off the battlefield.

75 percent of deaths among Napoleon's soldiers in 1812 were from typhus.

In the aftermath

of a victory over the French in 1743, about 1,500 British soldiers, uninjured but deathly ill, straggled into the army's general hospital in a village on the outskirts of Frankfurt, Germany. Men lay two or more to a bed and packed together on the floor. Most of the sick had dysentery, and everything was inevitably covered with excrement, urine, blood, sweat, and vomit. Fleas and lice abounded. Dysentery soon gave way to typhus. Hundreds died.

John Pringle, an army physician on his first campaign, observed the dying in horror. The ideas he developed for preventing illness became one of the earliest expressions of filth theory. It held, in brief, that filthy conditions foster diseases and that sanitation helps prevent them.

Born in 1707, Pringle was the youngest son of minor Scottish aristocracy. He had earned respect lecturing at the University of Edinburgh in moral and natural philosophy, which mostly meant learning about the living world through experimentation, observation, and inductive reasoning. When the War of the Austrian Succession began, he won appointment as physician general to the entire British force, 16,000 men. He soon proved his worth.

Pringle estimated that the British army lost a quarter of its strength to sickness alone during the 1743 campaign. He set out to change that, working through the military command to turn his insights into orders. In setting up campsites, quartermasters were told to avoid damp, poorly ventilated areas and to dig proper latrines in advance.

Hospitals were the soldiers' other great enemy. Pringle noticed that men treated in camp rather than in the general hospital typically avoided hospital fever, as typhus was called. Keeping them in camp became standard, where possible. In hospitals, patient space was to be clean, well ventilated, and a minimum of 36 square feet for each man. Bed linens were to be changed frequently. These reforms quickly paid off. Mortality at the general hospital fell by more than half, from 21.4 percent in 1743 to 9.8 percent over the next two years of fighting.

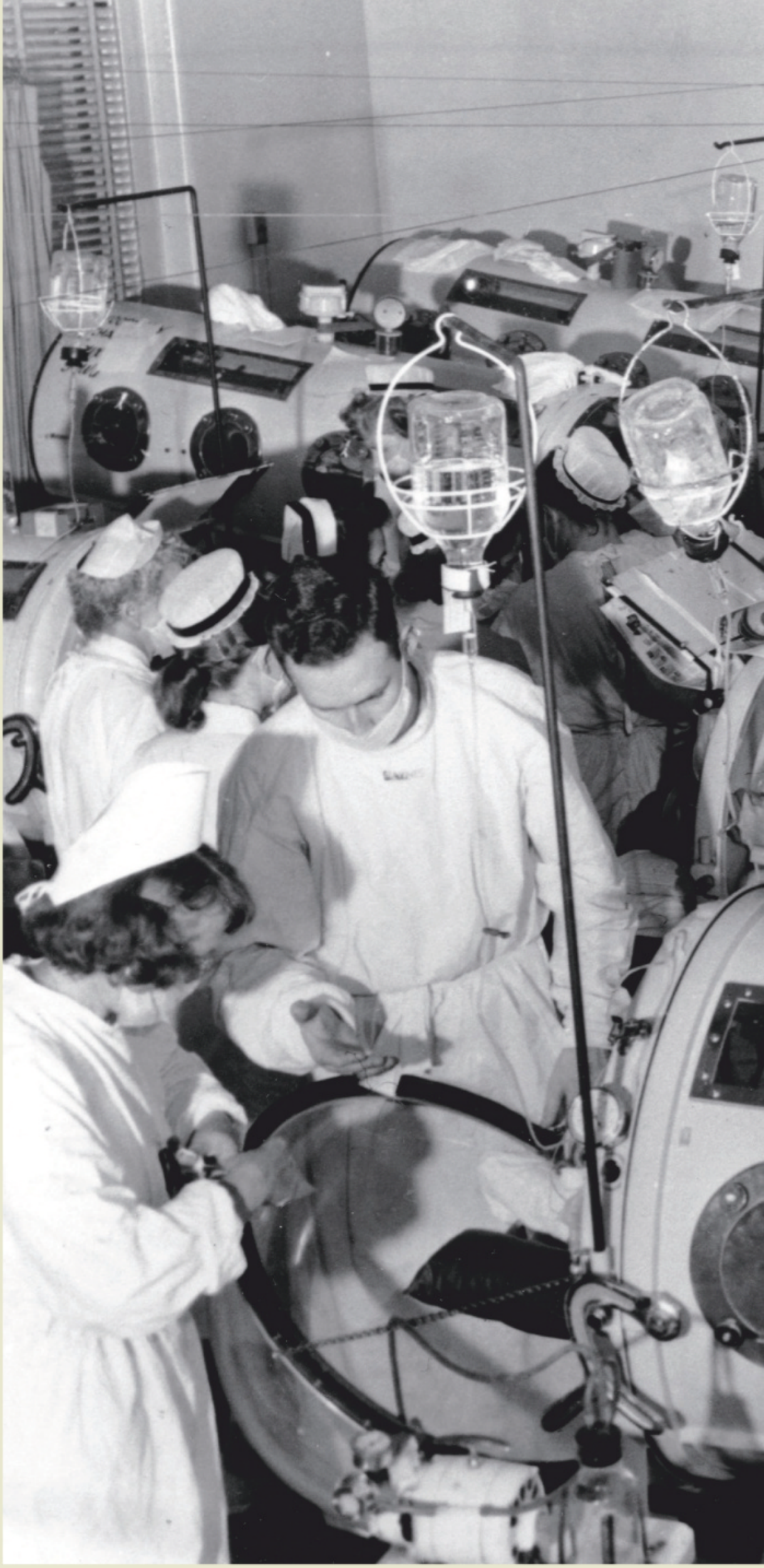
In 1752 Pringle published his book *Observations on the Diseases of the Army*. It went through multiple editions over the next two decades, spreading his sanitary gospel through the British military. In translation, it also reached French, German, and Italian armed forces. Recognizing filth theory's success in cleaning up the military, pioneering public health advocates soon began a new war on filth: in the rising cities of the industrial revolution.

IN FOCUS

Polio

A highly infectious virus that mainly affects children, polio has been eradicated in much of the world thanks to a global vaccination campaign. But the disease remains in a few pockets of Asia and Africa.

Before a vaccine became widely available in the late 1950s, polio paralyzed more than 15,000 people in the United States every year.



In an emergency ward at a Boston hospital, tanklike devices known as iron lungs help polio patients breathe during a 1955 outbreak. In the early 20th century, polio was one of the world's most feared diseases. Terrified parents saw their children suddenly stricken and sometimes paralyzed. When the virus attacked the muscles that control breathing, a patient was placed in an iron lung, a precursor to modern ventilators. In the spring of 1955, a vaccine was rolled out and led to a 99 percent decrease in cases worldwide.

AP PHOTO

Germ theory changes everything

Robert Koch

For 200 years, a gathering chorus of voices raised tentative versions of the idea that 'animalcules,' or germs, cause disease. Proponents of humoral medicine, and of filth theory, succeeded for a time in shouting them down.

But in the 19th century, as microscopes became more powerful and more widely distributed, other researchers began to open up the world of microorganisms. The idea that specific microorganisms could cause specific infectious diseases—and even decimate human societies—became more persuasive.

History tends now to honor two men, Louis Pasteur and Robert Koch, as the fathers of germ theory and forget the chorus whose work they built on. That's partly because human nature responds more to a few great names than to the cumulative and collaborative way most discoveries happen. But Pasteur and Koch were also masters of experimental science, meticulous about methods, and brilliant at choosing the right path from one experiment to the next. They hated each other as rivals in the same field of discovery—more human nature—and also as patriots at a time of war between their two nations, France and Germany. But the key breakthroughs they made carried humanity into the miraculous new world of germ theory.

Pasteur was a chemist, not a physician, an outsider perspective that proved useful for bypassing conventional medical beliefs. One of his studies in the 1850s started with the mundane goal of helping a local manufacturer identify the cause of an off taste in batches of beetroot alcohol. Pasteur quickly found the culprit, a type of bacteria, and recommended heating the beet juice to prevent it from happening again—arguably the beginning of pasteurization.

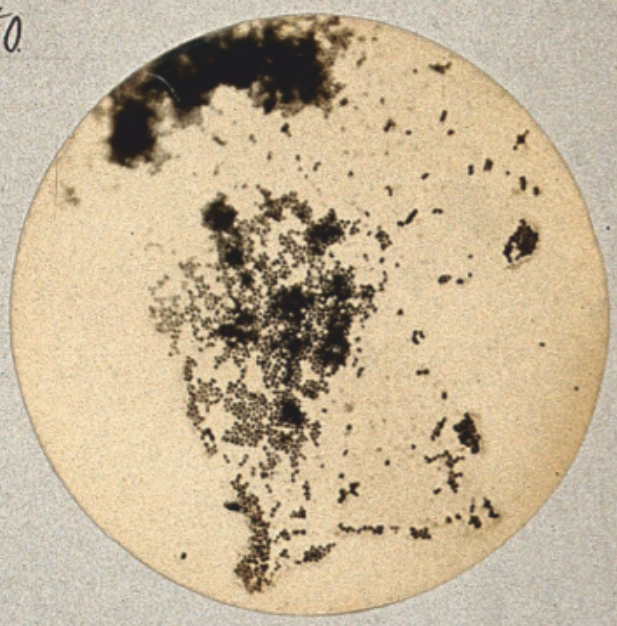
With his characteristic instinct always to look a little further, Pasteur proceeded to detail every stage of fermentation. It wasn't a purely chemical process, as many "modern" thinkers believed then, but a biological one: Yeast, a living organism, consumed nutrients in the brew and converted them to alcohol and other products. The work on fermentation encouraged Pasteur to see microorganisms everywhere and to demonstrate that they were a product of normal biological reproduction, not spontaneous generation. He went on to make a magnificent intuitive leap: Much as tiny living organisms caused fermentation—and unexpected organisms could spoil a batch—they could also cause infectious diseases.

B. Tuberculosis. x 750.

B. Tuberculosis. x 750

B. Anthracis. x 750

Actinomyces. x 150.



Micrococci, etc. x 750.

Micro organisms.

IN THE LATE 1800S, PHOTOGRAPHER ANDREW PRINGLE USED A MICROSCOPE TO CAPTURE IMAGES OF TUBERCULOSIS, ANTHRAX, AND OTHER BACTERIA.

WELLCOME COLLECTION,
ATTRIBUTION 4.0 INTERNATIONAL

Pasteur was an enthusiastic self-promoter. (Some modern historians say he also appropriated other people's work without credit, overstated his evidence, and lied about his methods.) He presented his findings in bold language and marshaled the resources of the French hierarchy in support of his work. He also engaged in fierce attacks on anyone foolish enough to disagree with him about anything, especially germ theory. But it took Robert Koch, then a small-town physician working alone in a home laboratory, to prove that Pasteur's magnificent intuition was correct.

Koch remains surprisingly little known today; most people are quicker to recognize the name of a minor assistant named Petri who invented a laboratory dish. Twentieth-century anti-German feelings may have turned the hero-making impulse away from Koch. He also lost some admirers when he divorced his wife to marry a beautiful young actress and, at about the same time, promised but failed to deliver a cure for tuberculosis.

Pasteur and Koch hated each other as rivals and as patriots at a time of war between France and Germany. But the breakthroughs they made carried humanity into the miraculous world of germ theory.

Koch deserves better. As a young physician in the mid-1870s in a rural area of what is now Poland, he marked off part of his examining room for a small laboratory. There, between patients, he studied microscopic specimens from the natural world—including blood from a sheep that had died of anthrax. By patient and persistent looking, he gradually unwrapped a hidden mystery about this veterinary disease, which sometimes also kills humans.

Bacteria normally reproduce by dividing in two. In favorable conditions, the repeated doubling of a pathogen such as anthrax can quickly overwhelm a host animal. What no one knew before Koch is that when conditions turn bad, anthrax bacteria can also produce a sort of escape pod. This spore, encased in a tough shell, can survive in the soil in a dormant state for generations, a biological land mine. That suggested an answer to how anthrax sometimes appears out of nowhere, when no new animal has entered a flock, and where no cases of the disease have happened for years or even decades.

Koch soon invented a way to grow the bacteria in an artificial culture, on a piece of glass he could study under his microscope. There he watched the emergence of the spores, and saw them become living bacteria again, with those bacteria subsequently producing a second generation of spores. To show that spores could infect animals after a period of dormancy, he injected them into wild mice—there were no laboratory mice then—quickly giving rise to a new and deadly population of anthrax bacteria.

Koch's October 1876 paper on anthrax bacteria was a turning point in human history. By repeatedly and predictably producing the symptoms of anthrax in experimental animals, he proved the long-contested reality of contagion and proved that *Bacillus anthracis* was the agent of that contagion. What he had demonstrated, in short, was the germ theory of disease.

Pasteur and Koch inevitably built on each other's work, while simultaneously attacking each other in public. Pasteur devised the first new vaccines in the 85 years since Jenner's smallpox vaccine, including ones for anthrax and rabies. Koch cured no diseases, but he went on to identify the pathogens that cause some of the most terrifying diseases known to humanity, including cholera and tuberculosis, for which he won a 1905 Nobel Prize. He also made many cures possible, by inventing microbiological tools other scientists still use to identify an astonishing rogues' gallery of deadly pathogens. For the first time, the targeted treatment and prevention of almost any infectious disease became possible.

Howard Florey

With the world engulfed in war, the drive to develop drugs against infection in the wounded took on new urgency, leading to the successful mass production of penicillin, the first effective antibiotic.

2.3 million doses of penicillin were manufactured in preparation for the D-Day landing.

Desperately ill,

Albert Alexander, a middle-aged police officer, lay in an Oxford, England, infirmary. It had started with a thorn scratch on his face as he tended his rose garden, according to a common account—or, as other evidence suggests, from a minor injury suffered in a German bombing raid. Now, though, he had lost an eye and was oozing pus all over from sepsis, an extreme and potentially lethal reaction to infection. He had at least come to the right place.

Researchers at Oxford University, led by Howard Florey, an Australian pathologist, and Ernst Chain, a biochemist who had fled Nazi Germany, were developing a promising new drug. On February 12, 1941, Alexander became the first patient to receive the treatment with the hope that it would cure him—and he soon rallied. But the drug was so hard to produce that the researchers had to painstakingly recycle it from his urine for reinjection. When the supply ran out, he died.

Years later, when penicillin became the wonder drug of the century, the media would lionize Alexander Fleming, a quiet microbiologist who first described the peculiar antibacterial power of the *Penicillium* mold and coined the name "penicillin" in a little-noticed 1929 research paper. But it was Florey and his team whose long struggle ultimately turned penicillin from a laboratory curiosity into a practical antibiotic.

That struggle took place in the shadow of conflict. World War II created intense pressure to deliver large quantities of what promised to be a lifesaver for soldiers wounded in battle. But *Penicillium* mold developed only in a thin film on a growth medium—while wartime needs called for a first run of 10,000 gallons.

The turning point came in July 1941, when the Rockefeller Institute, together with officials from the British and U.S. governments, wangled scarce plane seats for Florey and biochemist Norman Heatley to visit the institute in New York City. They soon found their way to the Northern Regional Research Laboratory in Peoria, Illinois, where the ambition was to grow penicillin in huge fermentation vats.

Corn steep liquor, a common by-product in the corn belt, turned out to be the ideal nutrient for growing penicillin cheaply, and a strain of *Penicillium* mold found on a rotten melon in a Peoria market proved better suited to growing in deep fermentation vats. Drug companies provided key funding, and in March 1944, Charles Pfizer and Company began producing a flood of penicillin at a former Brooklyn ice factory refurbished with 14 fermentors, each with a 9,000-gallon capacity. On June 6, 1944, Allied soldiers carried the antibiotic with them onto the beaches at Normandy and on across France. The lives it saved would soon help win the war.

IN FOCUS

Ebola

Since 1976, when it first emerged in Sudan and near the Ebola River in what is now the Democratic Republic of the Congo, the Ebola virus has reappeared periodically in central and western Africa.

Transmitted by contact with bodily fluids, Ebola causes hemorrhaging and organ failure. It kills about half of those who become infected.

Mourners carry the coffin of Liliane Kapinga Ebambe, a three-year-old who died of Ebola in July 2019 in Beni, a city in the eastern part of the Democratic Republic of the Congo. Despite extensive vaccination campaigns, the virus has persisted here, in part because of distrust of health officials, widespread misinformation, and festering violent conflicts. Liliane's parents believe their daughter was poisoned and that Ebola is a conspiracy by other countries to wipe out the Congolese people.

MARCO GUALAZZINI, CONTRASTO/REDUX

By the time infectious disease specialist Michael Callahan climbed aboard the *Grand Princess* in early March, he was already an old hand in the COVID-19 pandemic. He'd gotten his start in January trading notes in his tightly knit network of fellow experts about the emerging pathogen in Wuhan, China. He saw patients in Singapore as the disease was breaking out there, and he briefed U.S. government officials in Washington, D.C., on where it might occur next. He helped evacuate a cruise ship in Yokohama, Japan.

N95 masks are decontaminated inside a new system that allows single-use items to be reused safely. Developed by the nonprofit Battelle in Columbus, Ohio, the system applies vaporized hydrogen peroxide in a procedure that can be repeated up to 20 times on each N95 mask. It has been deployed in dozens of states.

BRIAN KAISER, NEW YORK TIMES/REDUX

Then he treated early victims as the disease spread to Boston, where he is a staff physician at Massachusetts General Hospital. And as he watched and worked, and brainstormed ventilator issues, he saw the disease reveal its "magnificent infectivity," its ability to sit "like a little silent smart bomb in your community," till it finds a person "and just takes them out."

"When I saw my 500th patient, I became terrified," Callahan says. "It's a sleeper."

For decades Callahan has been a familiar face on the front line of epidemics everywhere, working to end outbreaks of Ebola, SARS, H5N1, and a deadly alphabet soup of others. He fits his own description of experts who turn up on the scene of new outbreaks: "high-strung, fast-moving, compressed-speech people." Answering questions by phone for this story, he delivered lengthy, complex answers in high-energy bursts, with a dizzying tendency to hopscotch across the medical and geographical world.

But even among his highly skilled, hypermotivated colleagues, Callahan stands out for his ability to synthesize information in a crisis to quickly get to the best available option. As such, he's on speed dial for an array of organizations, from hospitals and global health nonprofits to the U.S. government, where he's the special adviser for COVID to the assistant secretary of preparedness and response. Now and then, he also gets home to his family in Colorado, where he works by phone and laptop, interrupted, like everyone else in mid-lockdown, by the dog barking, a child in need of bicycle repair, and the eternal call to neglected household chores.

Callahan chose this career path because of a brutal stint at refugee camps in eastern Democratic Republic of the Congo in the late 1990s. It taught him that infectious disease in the developing world is a "slow-rolling disaster. And it goes on forever. I became very driven by the unfairness of it all."

His subsequent experience with Ebola and other outbreaks in West Africa also taught him that treating one case at a time wasn't enough. Rather, providing training or supplies to local medical staff "would lead to huge changes in a village or community or hospital. And those changes would endure after you left."

That became his guiding philosophy. Working for a program run by the U.S. State Department, he helped physicians and scientists displaced from chemical and biological weapons programs in post-Soviet Russia retrain to become peacetime infectious disease researchers. That led to almost a decade at DARPA (the Pentagon's Defense Advanced Research Projects Agency). There he developed a program called Prophecy to predict and preempt emerging diseases.

Callahan's background has given him unusual insight into how we might adapt to COVID-19, and other emerging diseases that lie beyond. Protecting our health, he suggests, can depend on finding ways to help other countries meet their own needs, even if the national government is outwardly hostile and those needs might not always seem to serve our short-term national interests. It's about playing a longer game.

We have entered a frightening new world. Or maybe we are returning to the old world of our disease-plagued ancestors. Either way, the one great lesson we should take away is not to forget this happened.

In Indonesia, for example, overfishing has decimated coastal seafood stocks, and Islamic law prohibits eating pork. That makes maintaining a secure protein supply a major issue—especially after an outbreak of avian flu caused severe losses to the poultry business. So the Prophecy program at first quietly focused on protecting chicken stocks. Among other measures, it provided local gene-sequencing capability that allowed Indonesia to identify pathogens on its own, reducing dependence on Western powers.

It was the sort of initiative that might easily attract scrutiny from Congress, or from isolation-minded critics. But in Indonesia, "our equity went up," says Callahan, "and we got into the good stuff," meaning human pathogen surveillance. "DARPA, an otherwise secretive military agency, was a welcome partner."

Prophecy's other important strategy was to find smart young infectious disease physicians in developing countries and build lifelong relationships. That could mean supplying them with new technology, bringing them to U.S. medical schools for further training, or providing grants for new research.

"And by promoting the foreign partner, they get promoted themselves, and they become leaders in their field, and two things happen," Callahan says. "They develop host-nation sustainable funding. And you have a very grateful emissary who's now at the pinnacle of…pathogen intelligence."

One such foreign partner was a researcher in Russia Callahan had helped make the transition from bioweapons to disease detection. In 2005 that researcher's laboratory spotted an outbreak of H5N1, an avian flu that can devastate poultry and wild birds. It's also capable of jumping to humans and killing young people by destroying their lungs. It was moving northeast to where Asian and American flyways overlap in the Bering Strait region. The early alert enabled U.S. scientists to launch a major testing program on migratory birds in Alaska and prevent the disease from entering the continent.

The Prophecy program expired a few years after Callahan's time at DARPA ended. (DARPA's mission, says Callahan, is to invent new programs, not manage them. But some of the tools Prophecy introduced have gone on to help in quickly developing new vaccines and in predicting when diseases will become resistant to antimicrobial drugs.) The larger tendency

A coffin holding the body of a foreigner who died during the COVID-19 pandemic is stored in a mortuary in Milan until it can be sent to the nation of the deceased. Mortuaries in Italy's Lombardy region became so full that bodies were sent to other regions for cremation. Italian officials banned funerals nationwide, forcing families to mourn loved ones at home.

GABRIELE GALIMBERTI

among governments everywhere has been to discount the risk of pandemics and to underfund programs designed to prevent them. Thus, late last October, the U.S. government allowed Predict, another program focused on emerging diseases, to end. Less than a month later, the first known COVID-19 case occurred in China. And soon after, American victims began joining the worldwide ranks of the dead.

The current pandemic will almost certainly step up efforts to predict and control pandemic diseases, at least for a time. But no one knows yet what shape prevention should take, what it will cost, or how devastated economies will pay for it.

Will nations play the long game of international cooperation? Or will the trend to short-term national self-interest become more pronounced? Will a society that has barely quibbled about spending $13 billion on an aircraft carrier, largely in the service of preventing armed conflict, also accept spending on an even grander scale to prevent epidemic diseases? Will we continue to spend indefinitely, even though this kind of prevention means having nothing tangible to show for our money, no heroic physical object, just the unsatisfying knowledge that the catastrophe we feared did not happen?

We have entered a frightening new world. Or maybe we are returning to the old world of our disease-plagued ancestors. The one great lesson we should take away from history is this: When the current pandemic ultimately subsides, we cannot afford to forget that this happened. We cannot just move on. Somewhere on the planet, the next great pandemic, the next destroying angel, is already taking wing. □

Richard Conniff is at work on *Ending Epidemics*, a history of infectious disease discovery, for Princeton University Press. **Brendan Borrell** contributed additional reporting.

WATER EVERYWHERE

A 2,400-MILE TREK ACROSS INDIA REVEALS THE MYSTICAL LURE OF ITS SACRED RIVERS—AND A CRISIS THAT THREATENS A WAY OF LIFE.

BY **PAUL SALOPEK**

PHOTOGRAPHS BY **JOHN STANMEYER**

AND NOWHERE

The Guru Nanak Dev coal-burning power plant in Bathinda, Punjab, shut down in 2017 after 43 years. It helped power the state's mammoth irrigation needs, but it also blanketed Bathinda with coal ash, causing nasal, eye, and respiratory complaints and damage to local ecosystems.

PREVIOUS PHOTO

A man bathes away sin in the Ganges—amid a swirl of marigold offerings, plastic trash, and fecal waste. The river, sacred to Hindus and a vital resource to areas with large populations and little infrastructure, is one of the most polluted on Earth.

Homes, temples, and narrow alleyways in Varanasi's Old Quarter are demolished for a beautification project that will give pilgrims and tourists easier access to the Ganges. The workers who wield pickaxes and sledgehammers earn meager wages. The government offers compensation to displaced residents.

The hands of Resham Singh, a 59-year-old carpenter in Punjab, are gnarled from arthritis. Doctors say it may have been caused by exposure to water tainted by fertilizers and pesticides. Heavy use of chemicals in the 1960s to late 1970s brought India out of famine and into its green revolution, but Singh's village, Mari Mustafa, has high cancer rates.

'Do you do magic tricks?'

IT IS THE VILLAGERS OF RAJASTHAN. They watch us pass in the hot light of the Thar Desert. We are unwashed, covered in coarse dust, darkened by sun: charred scarecrows trudging across India with a cargo donkey. Local people mistake us for vagabond performers, traveling quacks, circus nomads. They believe we are sorcerers. The answer to their question is: Yes, of course. We carry magic. But then, so does everyone.

It lies in water.

Human beings are mobile wells of mildly salty water. As every schoolchild knows, our bodies contain roughly the same percentage of water that covers the Earth's surface. Such harmonies are no mystery. We are water animals born onto a water planet. Water is everywhere and nowhere. It is a restless element—unstill, on the move, always shifting its physical state from gas to liquid to solid and back again.

One oxygen atom. Two atoms of hydrogen.

Water molecules are bent like an arrow tip. Like an elbow. This helps give water a certain polarity, an infinitesimal charge on each end. This is how it collectively shapes our reality. It is the enchanted solvent and glue of our tangible world. It is the compound that both dissolves and binds our brain cells, mountain ranges, the steam wafting from our morning tea, and tectonic plates.

And yet there is so little to drink! The salty oceans hold roughly 97 percent of all the water on the globe. The poles and glaciers, though melting under the effects of climate change, lock up about 2 percent. Only an absurdly small droplet of the world's total supply, less than one percent, is available for human survival: liquid fresh water. And yet, we squander this treasure like fools lost in a desert.

I am walking across the world. Over the past seven years I have retraced the footsteps of *Homo sapiens,* who roamed out of Africa in the Stone Age and explored the primordial world. En route, I gather stories. And nowhere on my foot journey—not in any other nation or continent—have I encountered an environmental reckoning on the scale of India's looming water crisis. It is almost too daunting to contemplate.

The world's second most populous country, home to more than 1.3 billion people and a landscape defined by iconic rivers—the Indus, the Ganges, the Brahmaputra, and all their mighty tributaries—now teeters at the edge of a water emergency with unknowable consequences. Roughly a hundred million people in 21 Indian megacities, including Delhi, Bengaluru (Bangalore), and Hyderabad, may gulp their last groundwater dry by the end of this year. Farmers in northern India's Punjab, an important Asian breadbasket, complain that their relentlessly

Women strain to haul precious water from a well in Dongra, in the desert state of Rajasthan. Wells such as this replaced ancient stepped structures, where women had to walk down hundreds of stairs to reach available underground water.

overpumped water tables are dropping by 40, 60, even a hundred feet in a single generation. And the problem doesn't end with supply. Pollution in the form of industrial waste, urban sewage, and agricultural runoff has poisoned entire river systems. In total, some 600 million people—roughly half India's population—live without enough clean water. Meanwhile, 20 million human beings are born every year in India, each requiring water to live.

I trek for nearly a year and a half across the river plains of northern India. I plod over concrete highway overpasses, balance atop railroad bridges, and sit on my pack in tippy canoes, navigating river after river. There are hundreds. Each one, according to Hinduism, is sacred—a deity even. (The Ganges, or *Ganga* in Hindi, is a pale goddess depicted with as many as four arms, riding a crocodile.) The future of India churns within their silty currents.

"Will there be a magic show?" ask the people of the Thar.

Children skip alongside us, barefooted, laughing, squinting up against the desert sun. Sentinel khejri trees throw pale silver shadows onto the yellow ocher sands. The local wells are poisoned by too much iron and fluoride.

Magic? Sure. Let us call it the grand vanishing act.

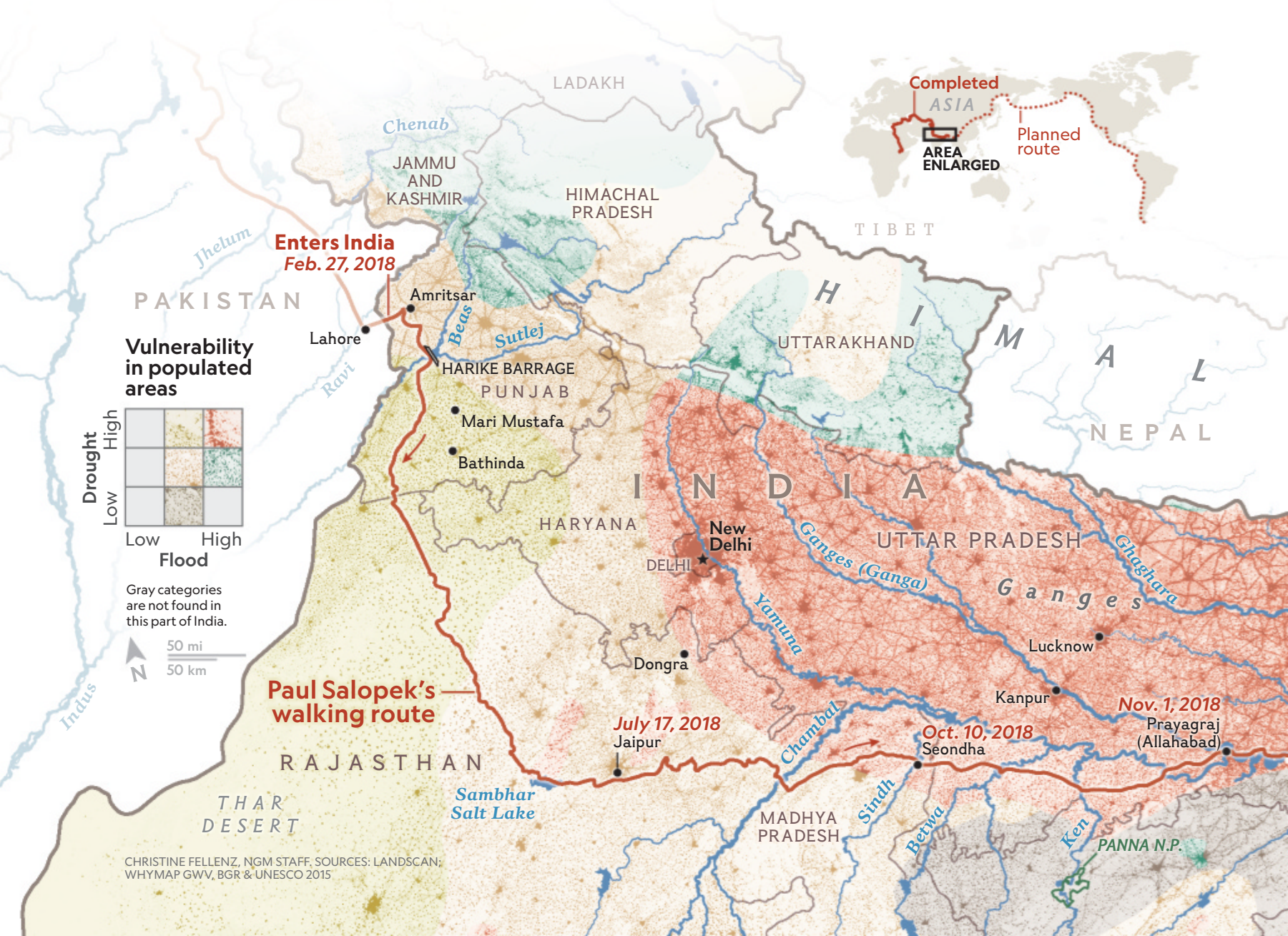
On the burned flats around Sambhar Salt Lake, in a dying wetland outside Jaipur, we spot hundreds of ragged figures moving in the distance. Hour after hour they walk backward, yanking wooden rakes over the white plain. Women salt workers. The quicksilver heat swallows up their spindly legs, delivers them back again. Infernal abracadabra. But it isn't, really. It's just us in a waterless world.

The Indus: River of rivers

INDIA—FROM *INDOS* IN GREEK, derived from *hind* in Persian, originating from the Sanskrit word *sindhu,* meaning river.

Where is the fabled Indus—river of rivers?

Where can one locate this immensely long, brawny waterway, born in the glaciers of Tibet—a gigantic, supple, living, liquid entity whose basin sprawls across nearly half a million square miles



of the Earth—a nurturer of ancient civilizations, a binational lifeline for millions of farmers in India and Pakistan? As I walk across the Indian state of Punjab, finding it is no simple task.

I join Arati Kumar-Rao, an environmental photographer, slogging the back roads south of Amritsar. Five large tributaries of the Indus ribbon across northwestern India. The Jhelum. The Chenab. The Ravi. The Beas. The Sutlej. We seek out the Beas. Soon we are lost. We blunder into a labyrinth of industrial agriculture.

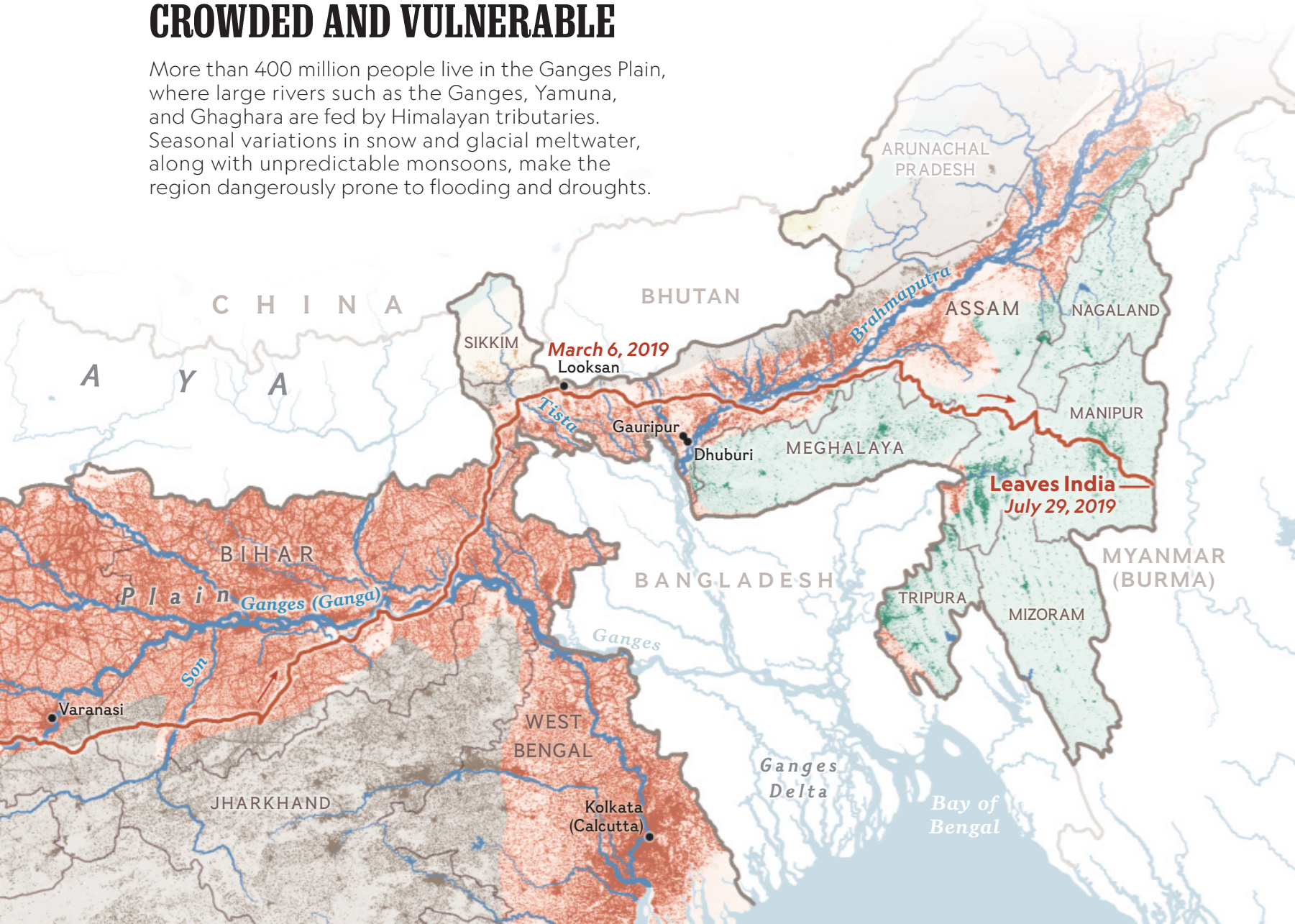
Each day is a furnace. We sweat around endless, steaming quadrangles of wheat. We pass Sikh temples topped with airy white domes, where volunteers offer simple meals of dal and rice to all passersby. We dodge armadas of chugging tractors. Each blasts Punjabi pop music at the sky through loudspeakers lashed to the operator's chair. Why? It's impossible to say. Can the drivers hear the music over their roaring engines? Aliens flying above Punjab would look down in wonder—with fingers plugging their ears. Cults of deaf humans (they would think) are performing some tireless ritual: etching the land in circles with machines, serenading the cosmos. But no: They are simply Punjabi farmers at work.

And then, dimly, I understand. We have found the Indus already! For days—weeks—we have been walking within the diffused presence of the river. Its currents have been diverted, bled off, channeled, diffused, parsed into countless canals, pipes, weirs, and furrows. This human-built capillary system has rendered the ancient green channels of the Indus tributaries largely irrelevant as geographical entities. Each of Punjab's billions of ripe wheat heads carries a drop of the Indus watershed in atomized form.

India was an early warrior in the green revolution. High-yield seeds, fertilizers and pesticides, tractors, and motorized well pumps have hugely increased crop yields since the 1960s. Once the poster child for famines, India feeds itself today. Its farmers sell the world torrents of grains and fruits. But this stunning victory against hunger has come at a steep cost. Agricultural chemicals pollute the tributaries of the Indus, possibly contributing to hot spots of diseases such as cancer. And the bill has come due for decades of unsustainable harvests: a staggering loss of finite quantities of groundwater. Farming is chancy in

CROWDED AND VULNERABLE

More than 400 million people live in the Ganges Plain, where large rivers such as the Ganges, Yamuna, and Ghaghara are fed by Himalayan tributaries. Seasonal variations in snow and glacial meltwater, along with unpredictable monsoons, make the region dangerously prone to flooding and droughts.



Cheap manual labor fuels India's economy. Clockwise from top left: Boatman Sarjeet Singh ferries people and provisions across the Beas River. Women pick tea leaves at Looksan Tea Estate, in West Bengal. A laborer conveys goods to boats that will transport them from Dhuburi to remote villages along the

Brahmaputra River. A villager returns from Dhuburi after fetching supplies by ferry for his community in Gauripur. Farmers harvest rice in Punjab, India's agricultural heartland. Women outside Dhuburi carry up to 200 loads of bricks, each load weighing about 70 pounds, on their heads every day.

Heavy machinery is used to scoop sand from the Son riverbed in Bihar. Although this operation may be legal, sand mining is often done illegally under cover of darkness. Sand supplies India's booming construction industry, but excessive mining disrupts rivers and destroys habitats of endangered species such as river dolphins and crocodile-like gharials.

Punjab. Millions are fleeing, emigrating to the Middle East, North America, elsewhere.

"It's hard not to feel overwhelmed," Kumar-Rao hollers on a canal road whining with tractors pulling house-size bags of chaff. She's spent years documenting the strip-mining of India's water resources. "Our denial is a form of mass blindness." Kumar-Rao wants to find another blind creature, the endangered Indus River dolphin—*Platanista gangetica minor*—a freshwater cousin of the famed sea mammal.

"There are no *bhulan* here anymore!" a dapper man calling himself Major Hindustani declares near the Harike Barrage. Bhulan is the local name for the Indus River dolphin.

Major Hindustani is a trick motorcycle rider. He works with a small traveling circus. With shirtsleeves rolled to display bulging biceps, he performs stunts for us—perching one-legged on the seat of his moving Royal Enfield—as we watch, stunned, on a quiet, muddy, relict bank of the Beas River. Walking India is like this. You meet all sorts of characters in unlikely places. But Major Hindustani turns out to be blind too. Kumar-Rao emits a squeal. She spots dolphins offshore. A cow and her calf. They rise and fall in the glossy brown currents of the Beas, breaking the surface with a sound like a soft kiss.

A recent survey suggests that no more than 11 Indus River dolphins live in the Beas.

The Chambal: Common injustice

GIVEN ENOUGH TIME, water defeats almost anything. Stone. Iron. Bone. Rivers saw through the stratigraphy of time itself. Yet patriarchy endures.

What is the most common injustice seen on a walk across the world?

Not the suppression of ethnic minorities. Not intolerance rooted in religion. Not income inequality. No: It is the exclusion of women from humanity's ledger of rewards and opportunities. No society is completely immune. Half of the

well over seven billion *Homo sapiens* alive today are denied equal access to political power, made to work harder, and compensated less—because they have two X chromosomes.

"Don't get me started," says Priyanka Borpujari, an independent reporter who joins the walk through the scenic Chambal River watershed in Rajasthan and Madhya Pradesh. "I'm the token 'brown women's issues' writer at many journalism conferences. Can't I be something else? An economics writer? A political analyst? A foreign correspondent?"

Before reaching the pink sandstone of the Chambal hills, we pause at a rice farm. It's managed exclusively by women. In testosterone-sodden India, this is interesting.

"We run things here. It is a necessity," says Saroj Devi Yadav, the flinty, 62-year-old matriarch. "All the men are away working in the city."

Yadav's husband delivers restaurant food in distant Jaipur. Yadav and her two teenage granddaughters stay home to water the fields. They cut fodder. They herd the cows and buffalo. They organize shipments of milk to the city in tin cans slung across motorbikes. It is much the same at nearby farms. As the sun drops over her tiny green domain, Yadav shares her tea and curry.

"I got married at 13," she says, flicking away the memory with her hand. "Things were different then. Nobody asked us girls. Today the girls get many more choices. They marry later."

It is an old story: the disruption of urbanization. The collision of diverse peoples in booming megacities cracks open age-old gender barriers. Yet in India, where up to two-thirds of the agricultural workforce are women, barely 13 percent of Indian women actually own land. Women carry the countryside's water. But India's natural resources remain cupped firmly in the hands of men.

The Chambal flows clean. It forms a sanctuary for gharials, the long-snouted crocodilians of India. The river's craggy headwaters once sheltered India's most famous woman bandit, Phoolan Devi, a Robin Hood figure who is said to have killed some 20 rival gunmen in a shootout.

"Hey!" Borpujari shouts.

It's a fat man steering an expensive SUV along a hot ribbon of blacktop. He brakes in front of us. He blocks our way. He films us out his window with a phone: two people among millions wandering the parched roadsides of India. Borpujari raises a hand.

"Did you ask our permission?" she demands.

"I didn't know"—the man huffs—"that I needed permission."

Borpujari plants herself at his window. She assumes a combative stance that—she later admits—she hates. She tells him levelly, "You need permission."

The Betwa: Sand miners

I WALK EAST FOR MONTHS. I move through the long golden core of Indian afternoons.

My GPS track unspools across the lean cow belt, through Madhya Pradesh and Uttar Pradesh, threading hamlets so forsaken by time they likely haven't seen a foreigner since independence in 1947. ("Are you an Englishman?" people ask.) I sleep on plank tables at roadside eateries called *dhabas,* or in rope beds in farmers' homes, or at mosques and Hindu temples. Without even knowing it—India's wrinkled river plains are smoothed by millennia of plowing—I inch from

The Kumbh Mela, a major Hindu festival, brings pilgrims to one of four river sites in India every three years. In 2019 crowds gathered in Prayagraj (Allahabad), at the confluence of the Ganges and Yamuna Rivers. Day and night, tens of thousands thronged the temporary bridges spanning the Ganges.

The family of Ramesh Pandey agreed to be photographed as they prepared to cremate him in Prayagraj on the bank of the Yamuna. His ashes will flow into the Ganges. Hindus believe that cremation at a holy site frees the soul from the cycle of life and death.

one watershed to another. There are dozens. They now feed the Ganga.

At a place called Seondha, an enormous fortress crumbles beside a placid bend of the Sindh River. The towering medieval gates bristle with foot-long iron spikes: defense against ramming by war elephants. A last descendant of the Bundela Rajputs who built the stronghold still lives in a rampart. Camped within its darkened walls for a night, I never see him.

By the sluggish brown currents of the Betwa River, I meet sand miners. They form a ragged army of lean men scooping out the riverbed with shovels and mechanical excavators. The sand may be trucked to construction sites as far as Lucknow and New Delhi, some 300 miles away. Many sand-mining operations are illegal. Sand is a lucrative commodity in India. It fuels a building boom, and a black market, that is both preyed upon and protected by goons, even as the plundering destroys aquatic habitats and disrupts hydrology. (A UN study calculates that humankind's growing appetite for humble construction sand—more than 40 billion tons a year—is double the volume of sediments being replenished naturally by the sum of the world's rivers.) Sand-mining mafiosi have killed law enforcement officers who've tried to halt the gutting of India's rivers. They've murdered reporters who have exposed the forbidden practice of excavating waterways.

"Keep walking," snaps my latest walking partner, river conservationist Siddharth Agarwal, as the miners shout at us to stop.

We feign deafness. We lope down to the Betwa's banks, hail a passing fisherman, fling our rucksacks into his dinghy, and paddle to the opposite side. We walk into the dark—cranking a 25-mile day to reach a village where bonfires, drums, and chanting announce a Hindu festival. The astonished celebrants welcome us. They prepare dal and roti. They lay out *charpais,* woven beds, for sleeping. This reflexive hospitality is universal along my path in rural India, a land that's hosted foot pilgrims since the Bronze Age. Agarwal asks, gingerly, about sand mining.

The villagers shrug. "What can be done?"

Mafiosi, politicians, cronies—they control life. True, the Betwa, stripped to its bedrock, floods more erratically than before. And yes, the unpredictable monsoons—climate change—have made farming even more marginal. People must dig thousands of small, rain-fed ponds to water their puckered fields. But the government is planning a dramatic rescue: diverting an entire river, the Ken, into the Betwa's channel to replenish its shrunken flow.

Author Paul Salopek rows along a section of the Ganges in Varanasi, Hinduism's holiest city. Although the murky water carries the ashes of some 30,000 people whose bodies are cremated there each year, the faithful believe it is pure enough to drink.

"River linking," Agarwal sighs. "False hopes."

India has earmarked some $2 billion to implement a controversial interlinking-of-rivers scheme: a massive water transfusion program that proposes to graft 30 major Indian rivers through more than 9,000 miles of concrete canals to ease the water crisis. Braiding the Ken to the Betwa will be the test case. Engineers plan to siphon off the Ken's "excess" monsoonal flows and funnel them to the "drier" Betwa. Several dams and barrages flooding 35 square miles of land are needed for this engineering to work. Environmentalists delivered a court battle.

"Where is all of this excess water?" Raghu Chundawat, a leading Indian conservationist, asks me sourly in nearby Panna National Park, a sanctuary for endangered tigers. "The government won't share its flow data. I don't think even they know what the impacts will be."

One known effect of turning the river gods into plumbing pipes: Most of the land submerged by the Ken-Betwa project lies within the tiger reserve.

The Ganga: Holy river

I HIKE THE BANKS of *Ma Ganga*—Mother Ganges—until her milewide currents arc north, cutting like a shining steel blade across the yellow

plains to Varanasi. Hinduism's holiest city is clouded in brick dust. Thousands of workers pummel the walls of Varanasi's Old Quarter with sledgehammers and crowbars, leveling antique alleyways and lopsided buildings for an urban beautification plan. Residents are evicted. The government gives them cash. Few appear happy. Reincarnation is hard.

Varanasi is known among devout Hindus as Kashi, or the place "where the supreme light shines." The holy city's 88 stone ghats tumble down to the Ganga in beautifully worn steps. At their bottom, devotees wash away sins in murky river currents, drinking and bathing in water that contains hundreds of times the safe levels of fecal bacteria. Tens of thousands of pilgrims each year come to die and be burned at the ghats. To be cremated in Varanasi is the surest way to achieve *moksha,* escape from the painful cycle of life and death. Dead babies and holy men without stain are exempted from the pyres. Their bodies instead are tied to flotsam and floated downriver. Or sunk in the Ganga with stones.

I sit and watch everything human—the brilliant garlands of marigolds and the feces—merge in the Ganga. The river is inky here with bone ash, a colossal stream that itself resists cleansing. At dawn, swallows spear the bronze air. I think of my dead and my wars. Varanasi is a good place to await the creation or destruction of the world. Or better, to get up and walk. Proclaim the devotional poems of Basavanna:

Listen, O lord of the meeting rivers,
things standing shall fall,
but the moving ever shall stay.

The Brahmaputra: Who is Indian?

THE RIVER is a road.

In Bihar I walk the drought-strangled Son. In West Bengal, it's the dam-starved Tista. The fabled Brahmaputra in Assam runs fat with rains and the runoff from disastrously melting glaciers. Men and women who look a thousand years old tread its sand banks, carrying baskets of rice. Past beached canoes. Past paddy fields shining in the hazy sunlight like old mirrors with their silver backing peeled off. The Brahmaputra slides by, a 1,800-mile conveyor of water that cascades over the curve of the world. Carrying billions of invisible fish, the click and hum of village noise, fear.

"Terrorists," hiss village drunks.

Siddharth Agarwal and I are questioned often in northeastern India. It's a sign of the times. Pakistan and India have clashed again over the contested Muslim territory of Kashmir. Xenophobia spikes. The Hindu nationalist government of Narendra Modi helps stoke it. In Assam I meet a friendly woman, Rupali Bibi, who hides like a fugitive. Why? Because she, a descendant of Bangladeshi Muslims who migrated to India nearly a hundred years ago, may be deported.

"A policeman brought a 'foreigner notice' to my house," Bibi, a rice farmer in her 40s, tells me in her cane-thatched home on the floodplain of the Brahmaputra. "He said, 'You are a suspicious person.'"

Like nearly two million others in the state of Assam, she has been excluded from the polarizing National Register of Citizens. The authorities don't accept her documents. The Indian government, meanwhile, offers a path to citizenship for religious refugees—barring Muslims. And during the early weeks of the COVID-19 pandemic, nearly 200 million Indian Muslims are demonized as disease carriers by right-wing Hindu politicians. Mobs armed with cricket bats reportedly target Muslims in Bengaluru.

Who is Indian? Who isn't? Can the diverse and secular India of Gandhi and Nehru survive a slide into tribal populism? It is impossible to say. The cosmos of rivers webbing India, of course, is mute on such matters.

I slog my last miles out of India through the summer monsoon. The rivers of Manipur, hard by the Myanmar border, rage white. Green hills speak the sibilant language of unbounded water—the rumble of waterfalls, the sighing of countless streams, the hard-knuckled rap of rain on tin roofs. Exhilarating sounds. Plucking at leeches, I recall the strangest river I encountered in India: the Saraswati. A "lost river" of myth exalted in Vedic scriptures. Some scientists believe it stopped flowing thousands of years ago, diverted by an earthquake or perhaps evaporated by climate change. I crossed its supposed bed in the desert of Rajasthan. A broad gully of dusty cobbles. A hot wind. Not a molecule of water visible. Drought-stunned farmers told me that government engineers were boring test wells nearby. They hoped to prove the river was real. ▯

Follow National Geographic Fellow **Paul Salopek**'s walk around the world at *OutofEdenWalk.org* and *natgeo.com*. **John Stanmeyer** has been documenting parts of the journey for the magazine.

1920 ▸ 2020

100 YEARS
OF
SUFFRAGE

THE FIGHT TO

By RACHEL HARTIGAN Photographs by CELESTE SLOMAN

BE HEARD

A CENTURY AFTER U.S. WOMEN WON THE RIGHT TO VOTE, WE CELEBRATE THOSE COURAGEOUS ACTIVISTS AND THEIR LEGACY.

Photo illustrations by **JOHANNA GOODMAN**

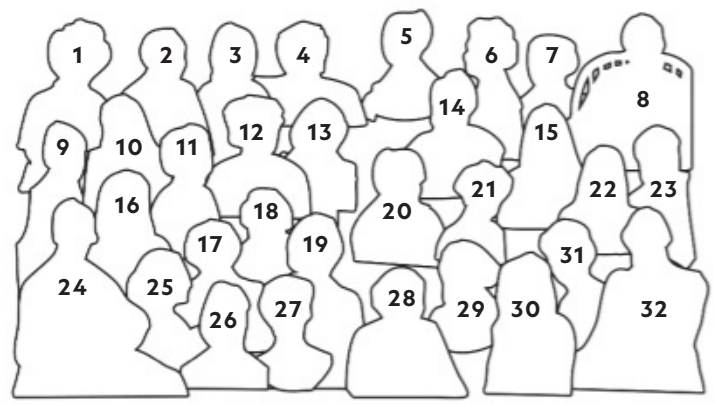
NATIONAL

On August 18, 1920, the day that Tennessee ratified the 19th Amendment, clinching its passage, suffragist leader Alice Paul unfurled the National Woman's Party ratification flag from the balcony of the organization's headquarters in Washington, D.C. Each time a state ratified the amendment, Paul sewed a star on the banner, until she had 36 and women had gained the right to vote.

LIBRARY OF CONGRESS (LOC)

PREVIOUS IMAGE

1. Congresswoman Shirley Chisholm
2. Suffragist Frances Ellen Watkins Harper
3. Labor leader Dolores Huerta 4. Politician and voting rights activist Stacey Abrams
5. Abolitionist, suffragist Lucretia Mott
6. Educator, civil rights activist Mary Church Terrell 7. Suffragist Therese A. Jenkins
8. Justice Ruth Bader Ginsburg 9. Hawaiian suffragist Wilhelmina Kekelaokalaninui Widemann Dowsett
10. Congresswoman Sharice Davids
11. Congresswoman Patsy Mink
12. Suffragist Carrie Chapman Catt
13. Civil rights activist Diane Nash
14. Journalist, civil rights activist Ida B. Wells
15. Labor organizer Ai-jen Poo 16. Virginia delegate Danica Roem
17. Congresswoman Susan W. Brooks
18. Educator, suffragist Milagros Benet de Newton 19. Justice Sandra Day O'Connor
20. Abolitionist, suffragist Elizabeth Cady Stanton
21. Congresswoman Jeannette Rankin
22. Youth activist Edna Chavez 23. Historian, writer Paula Giddings
24. Abolitionist, activist Sojourner Truth
25. Indian rights activist Zitkala-Sa 26. Suffragist Virginia Minor 27. Suffragist Mabel Ping-Hua Lee 28. Activist Mary McLeod Bethune
29. Abolitionist, suffragist Frederick Douglass
30. Feminist Gloria Steinem 31. Suffragist Alice Paul 32. Suffragist Susan B. Anthony



LOC (1, 5, 12, 18, 20, 21, 26, 29, 31, 32); NEW YORK PUBLIC LIBRARY (2); ZACK DEZON, CONTOUR/GETTY IMAGES (3); ELIJAH NOUVELAGE, *WASHINGTON POST*/GETTY (4); LOC/CORBIS/VCG/GETTY (6); HISTORIC COLLECTION/ALAMY STOCK PHOTO (7); ANDREW HARRER, BLOOMBERG/GETTY (8); NATIONAL PARK SERVICE (9, 14); WHITNEY CURTIS, GETTY (10); RALPH CRANE, LIFE PICTURE COLLECTION/GETTY (11); LEIGH VOGEL, GETTY (13); VALERIE MACON, AFP/GETTY (15); PAUL J. RICHARDS, AFP/GETTY (16); DOUGLAS GRAHAM, CQ ROLL CALL/GETTY (17); KEYSTONE/CONSOLIDATED NEWS PICTURES/GETTY (19); GREGG DEGUIRE, FILMMAGIC/GETTY (22); MARION ETTLINGER, CORBIS/GETTY (23); NATIONAL PORTRAIT GALLERY, SMITHSONIAN INSTITUTION (24); DIVISION OF WORK AND INDUSTRY, NATIONAL MUSEUM OF AMERICAN HISTORY, SMITHSONIAN INSTITUTION (25); *NEW YORK TRIBUNE*/LOC (27); STATE ARCHIVES OF FLORIDA (28); LBJ PRESIDENTIAL LIBRARY (30). BACKGROUND IMAGES: LOC (ALL), EXCEPT BUYENLARGE/GETTY; AMERICAN CATHOLIC HISTORY RESEARCH CENTER AND UNIVERSITY ARCHIVES, TERENCE VINCENT POWDERLY PHOTOGRAPHIC PRINTS; PHOTOQUEST/GETTY; BETTMANN/GETTY

‘WELL I HAVE BEEN & GONE & DONE IT!!’

SUSAN B. ANTHONY WROTE TO A FRIEND ON NOVEMBER 5, 1872.

THAT DAY ANTHONY and her three sisters managed to vote in Rochester, New York. Nearly a century after the nation’s founding, seven years after the end of the Civil War, and two years after the 15th Amendment granted voting rights to African-American men, it was still illegal for most women to vote. Anthony and her sisters had been sure they would be denied. Indeed, that’s what they had hoped would happen. They wanted grounds for a lawsuit.

But Anthony, a well-known and intimidating figure, couldn’t help herself. A few days earlier, she had browbeaten the young officials who were registering voters at a local barbershop into putting the women’s names on the voting rolls. When that proved an unexpected success, she spread the word.

On Election Day, some 15 women in Rochester voted. “We are in for a fine agitation in Rochester,” wrote Anthony to her friend and fellow campaigner Elizabeth Cady Stanton. Although she hadn’t expected to vote, she knew her defiant act would have ramifications.

Two weeks later, the opportunity she’d been aiming for arrived on her doorstep in the form of a well-mannered federal officer. He was there to arrest her.

By that point women had been campaigning to

Coline JENKINS

Great-great-granddaughter of Elizabeth Cady Stanton and co-founder of the Elizabeth Cady Stanton Trust

Suffragist Elizabeth Cady Stanton always looked forward; her descendant Coline Jenkins does too. A longtime supporter of the Equal Rights Amendment, Jenkins also is a town legislator in Greenwich, Connecticut. The trust she co-founded has amassed a collection of suffrage artifacts to preserve history, educate the public, and promote democracy. She successfully campaigned to have statues of Stanton and fellow activists Susan B. Anthony and Sojourner Truth erected in New York City's Central Park.

Kenneth B. MORRIS, JR.

Great-great-great-grandson of Frederick Douglass and president of Frederick Douglass Family Initiatives

Frederick Douglass was the only man to speak at the first women's rights convention, and Morris is proud to be his descendant. But he's equally proud of Anna Douglass, who sold her possessions to finance her future husband's escape from slavery. When Morris learned how much slavery still exists in the world today, he decided to use what he calls "the historical significance of my ancestry" to do something about it—founding Frederick Douglass Family Initiatives, which fights human trafficking through education.

Michelle DUSTER

Great-granddaughter of Ida B. Wells and a writer, speaker, educator, and activist

As the youngest child of suffragist Ida B. Wells, Duster's grandmother watched Wells "just fighting, fighting, fighting all the time," Duster says, and feeling "dejected and demoralized." As a result, Duster's grandmother turned away from activism, but Duster, the author of two books on Wells, eventually found her way to it. She was a leading member in the campaign to raise money for a monument to Wells in her adopted hometown of Chicago and worked to get a major downtown street named after her.

get the vote for decades. They'd begun to question their subordinate role in society, rallied to improve women's rights within marriage, and called for universal suffrage. They'd ventured beyond the domestic sphere of their homes and neighborhoods, into spaces where no "respectable" women would go, and had spoken in public before mixed crowds, which no respectable women would do. They'd inserted themselves into a political process that made no room for them. They'd insisted on what they believed were their rights as citizens. They'd elevated women's voting rights to an issue that national politicians could no longer ignore.

And yet, they still had a very long road to travel—a nearly half century–long campaign to press their cause across the country. The 19th Amendment, which decreed that no citizen could be denied the right to vote based on sex, became law on August 26, 1920—a tremendous accomplishment. Some 27 million women became eligible to vote, the largest increase in potential voters in American history. But the victory was incomplete: Because of restrictive state and federal laws such as poll taxes, literacy tests, and ethnic barriers to citizenship, many nonwhite women—African Americans, Native Americans, Latinas, and Asian Americans—still didn't have access to the ballot. Nor did many nonwhite men, despite the 15th Amendment.

It's easy to consign the suffragists to the past—to imagine them as severe Susan B. Anthony and

"When the ballot is put into the hands of the American woman the world is going to get a correct estimate of the Negro woman," wrote Nannie Helen Burroughs (left, holding banner). Many organizations run by African-American women campaigned for the vote, including the Woman's Auxiliary to the National Baptist Convention, which Burroughs helped found. LOC

fussy Elizabeth Cady Stanton, stiffly posing in a black-and-white portrait or as long-skirted women brandishing quaint banners, demonstrating for something we take for granted. After all, more women now vote than men, nearly 10 million more in the 2016 presidential election. Nancy Pelosi, the speaker of the U.S. House of Representatives, is one of the most powerful people in the country. Hillary Clinton won the popular vote for president in 2016, and six women competed to be the Democratic nominee in 2020.

★★★★★

BUT THE PAST is still with us. My grandmothers were born into a world in which they couldn't vote. A girl born in the United States today arrives in a country that a woman has never led. Nearly 51 percent of the population is female, but far fewer women hold elected office than men. Efforts to limit who can vote persist. Clinton lost to a man known for sexist behavior, and none of those female presidential candidates made it to the top of the ticket. The campaign for political equality that began in the 19th century shows no sign of being over in the 21st.

THE PAST IS STILL WITH US. MY GRANDMOTHERS WERE BORN INTO A WORLD IN WHICH THEY COULDN'T VOTE.

The push for women's suffrage began in 1848 in part because Stanton, a socially active woman from a prosperous and prominent family, was chafing at her circumscribed life. Stanton had moved from Boston to the small town of Seneca Falls, New York, for the health of her husband, Henry, an abolitionist who began leaving her alone with their three sons as he traveled the state agitating against slavery. As much as she loved her children—she would end up having seven—Stanton found the limitations on what women were able to achieve maddening.

"I suffered with mental hunger," she later wrote.

When Lucretia Mott, a noted Quaker abolitionist, came to the area for a visit, Stanton welcomed the chance to see her. The two had met several years earlier at an antislavery convention in London. Over tea with Mott and a few friends, Stanton "poured out the torrent of my long-accumulating discontent," she wrote, "with such vehemence and indignation that I stirred myself, as well as the rest of the party, to do and dare anything."

What they dared to do was organize their own convention, the first to be held on women's rights in the U.S. They did it quickly, in little more than 10 days, because Mott, the most experienced activist of any of them, would be leaving soon.

The women drafted a "Declaration of Sentiments" to be presented to the convention

Erin
LOOS CUTRARO

Founder and CEO of She Should Run

Women hold fewer than one-third of federal and state legislative and executive elected offices in the U.S. With her nonpartisan group, Cutraro hopes to shift the balance by finding "that woman who is getting it done in her own way, in her community, in her workplace, but is not yet even considering elected office as a possibility." With online leadership training and networking, her organization helps women explore that possibility—and prepare to pursue it.

Christabel
CRUZ

Director of New Leadership at the Center for American Women and Politics at Rutgers University

Cruz casts the nonpartisan program that she oversees as a way of "making sure that college women have the tools they need to become responsible public leaders." In more than 20 states, college students from two- and four-year schools are recruited for workshops that coach them in political skills, such as networking and public speaking, and encourage them to think about how they can advocate for their communities. "Most women are leaders," says Cruz. "They just need the tools and the resources and the push to see themselves that way."

Jennifer PIEROTTI LIM

Ariel HILL-DAVIS

Co-founders of Republican Women for Progress

"Nowadays there's so much great focus on women's representation and getting more women elected," says Lim (above, at left). "That has to include Republican women." Their numbers in Congress fell after the 2018 elections. Lim and Hill-Davis, two of the four founders of the organization, are determined to reverse that slide through recruitment and training. "We have a lot of women who come from a more traditional background," says Hill-Davis. She says her group's job is "convincing them that they're just as capable as the men and that their life experience brings something different to the table that is no less valuable."

for approval. Modeled on the Declaration of Independence, the document decried men's "absolute tyranny" over women, citing grievances that reflected the very limited rights women had in the United States then.

Married women, for example, were "civilly dead" because they did not have legal rights separate from their husbands', nor could they own property or even keep the wages they'd earned themselves. Colleges were closed to women; so were professions. Man, the declaration stated, "has endeavored, in every way that he could, to destroy [woman's] confidence in her own powers, to lessen her self-respect, and to make her willing to lead a dependent and abject life."

Appended to the declaration were resolutions that claimed equality for women on many fronts, but Stanton realized that without political power, these positions just amounted to wishful thinking. What women needed was the vote. She added this resolution: "That it is the duty of the women of this country to secure to themselves their sacred right to the elective franchise."

FOR A TIME SUFFRAGISTS AND ABOLITIONISTS WORKED TOGETHER. AFTER THE CIVIL WAR, THEY SPLIT OVER WHOSE RIGHTS CAME FIRST.

Several hundred people attended the two-day meeting. Roughly a hundred signed the declaration, but many balked at the resolution advocating suffrage. Mott feared that pursuing the vote would "make us ridiculous." Politics were considered excessively corrupt for women and perhaps, for some, a step too far out of the domestic domain.

But Frederick Douglass, who had fled slavery and founded the *North Star* antislavery newspaper in nearby Rochester, spoke in support of it. As he wrote in his account of the convention, he believed "if that government is only just which governs by the free consent of the governed, there can be no reason in the world for denying to woman the exercise of the elective franchise."

The resolution passed, and the campaign for American women's right to vote had begun.

★★★★★

EIGHTEEN YEARS LATER, in 1866, Frances Ellen Watkins Harper, a poet and novelist, took the stage at the Eleventh National Women's Rights Convention in New York City. The Civil War was over, the Union had won, and now the burning question was how emancipated people would be incorporated into the reunited country. Women wondered whether that solution would include them.

At the meeting, Harper spoke of the injustices she'd experienced as a woman, telling the crowd that when her husband died suddenly, all their property had been taken away from her. She also recounted the wrongs she'd suffered as an African American.

The listeners, most of them white women, gasped when Harper described the brutality she had experienced while traveling by streetcar and train. She impressed upon her audience that for her and many like her, their rights as women and their rights as African Americans could not be disentangled—and that the two causes must be aligned.

"We are all bound up together," Harper said, "in one great bundle of humanity."

And, for a time, they were. The seeds for women's suffrage first grew among the abolitionists, with people such as Mott, Stanton, Douglass, and Sojourner Truth active in both causes. They were united in their wish to be treated as full citizens of the United States. But after the Civil War, the groups fractured over whose rights came first.

★★★★★

WHAT THE SUFFRAGISTS wanted was universal suffrage. "No country ever has had or ever will have peace until every citizen has a voice in the government," Stanton declared. But many states were reluctant to cede their authority over who could vote. So the 14th and 15th Amendments, two of the amendments addressing African-American rights, were drafted to

PHOTOS: CHIP SOMODEVILLA, GETTY IMAGES (PELOSI, MIKULSKI); STAN WAYMAN (MINK), MARK KAUFFMAN (SMITH), LIFE PICTURE COLLECTION/GETTY IMAGES; MPI/GETTY IMAGES (RANKIN)

★ MORE WOME THAN EVE

Of the more than 12,000 lawmakers who in Congress since 1789, only 366 have b Recent elections have led to the high female representation in Congress in U 24 percent. The U.S. ranks in the middle ra tries globally when it comes to women's re

BY MONICA SERRANO

LAWSON PARKER. SOURCES: CENSUS; CENTER FOR AMERICAN W
INCLUDE NONVOTING DELEGATES AND RESIDENT COMMISSION

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Nancy Pelosi
(D-California)
When she became the first female speaker of the House of Representatives, she said: "I've broken the marble ceiling."

Barbara Mikulski
(D-Maryland)
The longest serving female lawmaker won 10 congressional elections. She spent a decade in the House and 30 years in the Senate, retiring in 2017.

Patsy Mink
(D-Hawaii)
Mink was the first woman of color and first Asian-American woman elected to the House of Representatives.

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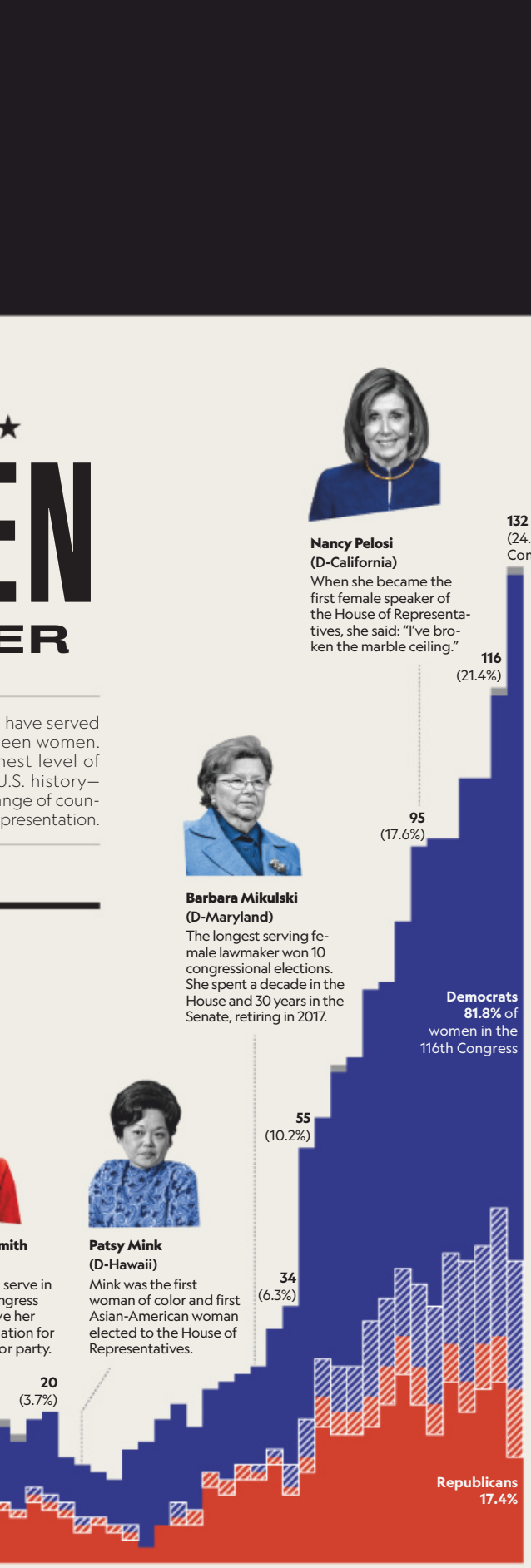

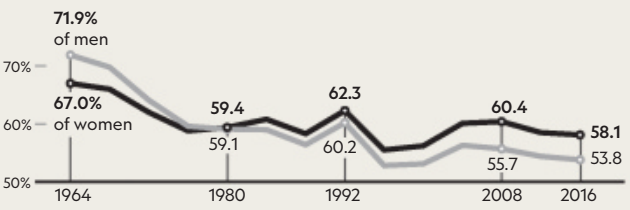

OMEN AND POLITICS; HISTORY, ART & ARCHIVES, U.S. HOUSE OF REPRESENTATIVES. GRAPHIC DATA
ERS.

5

SUFFRAGISTS ★ YOU MAY NOT ★ KNOW

PAGE 110

ON THE ANNIVERSARY OF THE 19TH AMENDMENT, A CLOSER LOOK AT THE WOMEN WHO FOUGHT

Mabel
PING-HUA LEE

Suffragist and advocate for the Chinese immigrant community

A Chinese immigrant, Lee became an advocate for women's rights at a young age, leading a 1912 New York City suffrage parade on horseback when she was 16. The first Chinese woman to get a Ph.D. in economics at Columbia University, Lee wouldn't gain the right to vote until 1943, when Chinese immigrants finally were allowed to become U.S. citizens.

LOC (GRADUATES; LIBRARY; PARADE, BOTTOM RIGHT); BETTMANN/GETTY IMAGES (PARADE, LEFT); PHOTOQUEST/GETTY IMAGES (PARADE, TOP RIGHT) ALAMY (SUFFRAGE ASSOCIATION). ALL IMAGES IN FOREGROUND AND FRAMES, UNLESS OTHERWISE NOTED: METROPOLITAN MUSEUM OF ART; PIXABAY (FLOWERS, FLAGS, BIRDS)

Milagros
BENET DE NEWTON

Puerto Rican educator and suffragist

The 19th Amendment didn't give women the right to vote in Puerto Rico, a U.S. territory. Newton, a conservative educator from an influential family, joined forces with other Puerto Rican women to boost the suffragist cause. They succeeded in getting the vote for literate women in 1929 and for all women in 1935. Residents of Puerto Rico still can't vote for president.

LOC (SAN JUAN); BETTMANN/GETTY (SUFFRAGISTS)

Wilhelmina KEKELAOKALANINUI WIDEMANN DOWSETT

Hawaiian suffragist

A member of Hawaii's royal family, Dowsett successfully pushed for the chance to have Hawaiians, not the U.S. government, decide whether women could vote in elections there; it was a territory at the time. The Hawaiian Senate passed a suffrage bill in 1919, but the House balked. Hawaiian women had to wait until the 19th Amendment for suffrage.

PIXABAY (HAWAII MOUNTAINS); WATERFRAME/ALAMY (FLAG); MEGAN SPRINGATE, NATIONAL PARK SERVICE (STAR); SMITH COLLECTION/GADO/GETTY (AMENDMENT); LOC (SUFFRAGISTS); KEVIN SCHAFER, ALAMY (BIRD)

Zitkala-SA

Writer, musician, and advocate for Native American rights; also known as Gertrude Simmons Bonnin

A member of the Yankton Dakota Sioux, Zitkala-Sa gave a speech advocating women's rights when she graduated from the missionary boarding school she attended. As an adult, she argued for Native American citizenship, which was granted in 1924, and founded the National Council of American Indians to unite tribes in the fight for the vote.

BETTMANN/GETTY (ZITKALA-SA); NATIONAL PARK SERVICE (RESERVATION VIEW); GERTRUDE KÄSEBIER, NATIONAL MUSEUM OF AMERICAN HISTORY, SMITHSONIAN INSTITUTION (ZITKALA-SA WITH VIOLIN); LOC (BUILDING); NATIONAL ARCHIVES (CITIZENSHIP DOCUMENT); FRANK MUCKENHEIM, ALAMY (VIOLIN)

Mary McLEOD BETHUNE

Educator and civil rights activist

Born to former slaves in 1875, she became the most politically powerful black American woman of her time. After the 19th Amendment passed, she organized black voter registration drives, defying threats by the Ku Klux Klan. She advised President Franklin Roosevelt and was the only black woman at the UN's founding conference.

CARL VAN VECHTEN COLLECTION/GETTY IMAGES (BETHUNE); SMITHSONIAN NATIONAL MUSEUM OF AFRICAN AMERICAN HISTORY AND CULTURE (BANNER); LOC (WOMEN'S ARMY LOGO, ROW HOUSE); STATE ARCHIVES OF FLORIDA (CABIN); NATIONAL ARCHIVES (PHOTOGRAPH, BUST)

prohibit states from denying the franchise to eligible voters, who were explicitly defined for the first time as male.

Stanton and Anthony refused to support the 15th Amendment because it removed race but not sex as a barrier to voting. Turning away from longtime friends and allies such as Frederick Douglass, Stanton decried granting the franchise to "Patrick and Sambo and Hans and Yung Tung" rather than to "women of wealth and education," whom everyone understood to be native-born whites.

THE 15TH AMENDMENT REMOVED RACE AS A BARRIER TO VOTING, BUT IT EXPLICITLY DEFINED VOTERS AS MALE.

Not all white suffragists took that route. Some saw an opportunity in the 14th Amendment, which was ratified in 1868 and granted citizenship to "all persons born or naturalized in the United States." That included recently freed slaves. Arguing that citizenship should include the right to vote, hundreds of women, along with Anthony, showed up at the polls in the early 1870s, with uneven results. After her arrest for voting in Rochester, Anthony hoped to take her case to the Supreme Court, but a technicality squashed that plan.

Of all the attempts to exercise the franchise, Virginia Minor's bid to register to vote in St. Louis proved to be the most significant. When she was denied, the Missouri suffrage leader sued the election official in charge—or rather, her husband sued him because, as a woman, she did not have the legal right to do so. Her case, *Minor* v. *Happersett,* made it to the Supreme Court, where the Minors argued that the state of Missouri had violated the 14th Amendment by abridging her privileges as a citizen, which included the right to vote.

The outcome was devastating. The court ruled that "the Constitution of the United States does not confer the right of suffrage upon anyone."

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ccepted by the Supreme Court, says llen Carol DuBois, author of *Suffrage: ong Battle for the Vote,* "we ourselves be in the situation where states are depriving people of the right to vote, all voter suppression." If Minor had uld have set a strong precedent for uffrage.

Ida B. Wells, a journalist and civil rights leader in Chicago, refused to be shunted to the sidelines. Woodrow Wilson had just been elected president, and Alice Paul, a young militant, organized a large suffragist parade in Washington, D.C., on the day before his inauguration.

Paul, who would go on to lead the National Woman's Party, was intent on launching a nationwide campaign. In a strategic move with far-reaching ces, she and other white voting rights oted to cultivate the support of south- women—and to diminish the role of en.

d faced off against lynch mobs in Ten- . founded the first African-American uffrage group in Chicago. She was one ngest voices for women's suffrage in ut when she arrived in Washington rade, she was told she would not be with the Illinois delegation. Instead, bring up the rear of the procession black women. She refused.

inois women do not take a stand now at democratic parade, then the col- en are lost," she declared. Her voice with emotion and her face was set in m determination, according to news- rts. "I shall not march at all unless I under the Illinois banner."

e parade began, Wells wasn't in it. ay through, she walked out of the assumed her place among the Illinois o one dared remove her. When Illinois e vote to women later that year, she tration drive among African Ameri- ventually helped elect the first black n Chicago.

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Nicole MONTCLAIR-DONAGHY

Executive director, North Dakota Native Vote

In the six weeks before the 2018 elections, Montclair-Donaghy put 3,000 miles on her car driving across North Dakota to ensure Native Americans could vote. Her organization was founded in response to a state requirement that voters show an ID with a residential street address, which people on reservations often don't have. It also seeks to inspire Native Americans to vote. "We are a matriarchal society," says Montclair-Donaghy, a Hunkpapa Lakota. "Most of the work being done at a grassroots level is led by women."

In January 1917 female suffragists began standing quietly outside the White House six days a week, with only their banners declaring their cause. Known as the Silent Sentinels, the protesters were determined to shame President Woodrow Wilson into supporting a federal suffrage amendment. The women endured all kinds of weather, harassment from passersby, and eventually, arrest and imprisonment.

LOC

MR. PRESIDENT
HOW LONG
MUST
WOMEN WAIT
FOR LIBERTY

the Advancement of Colored People (NAACP). A prominent Washington educator, she chose to demonstrate her solidarity by marching in the procession with Delta Sigma Theta, a newly formed African-American sorority from Howard University. One hundred years later, in 2013, the influential organization staged an anniversary suffrage march. This time sorority members led the procession.

★★★★★

AT THE TIME of the original parade in March 1913, nine states, all in the West, had passed laws allowing for the enfranchisement of women. Several more, including Illinois, were on the brink of doing so. Elected officials now had women as their constituents, women they had to answer to. The time was ripe to push for an amendment to the U.S. Constitution.

But President Wilson did not show much inclination to support women's right to vote. After Wilson was reelected in 1916, Paul ratcheted up the pressure, recruiting activists, including Terrell and her daughter Phyllis, to stand silently in front of the White House, many holding signs that read "Mr. President what will you do for woman suffrage?" and "How long must women wait for liberty?" These picketers—known as the Silent Sentinels—were treated with curiosity at first; no one had ever protested the president like that.

Things took a more violent turn once the United States entered World War I in April 1917. Dissent was seen as disloyal, and people ripped the banners from the protesters' hands and spit on them. At one point a mob chased them to the nearby headquarters of the National Women's Party, where the crowd tried to pull women from the balcony.

Rather than protecting the protesters, police arrested them for blocking traffic or, in the case of Alice Paul, just for walking toward the demonstration. Most of the women were jailed at the Occoquan Workhouse prison in Lorton, Virginia, but Paul was put in solitary confinement at the D.C. jail, where she went on a hunger strike for three weeks. She was tied down and force-fed by a tube thrust up her nose. "I confess I was afraid of Dr. Gannon, the jail physician," she said later. "I dreaded the hour of his visit."

Conditions were no better at Occoquan. Some 15 women went on hunger strikes, and a few of them were force-fed. "Food dumped directly into stomach feels like a ball of lead," said Lucy Burns, who led the imprisoned women. On what became known as "the Night of Terror," Burns was handcuffed to her cell door overnight, while other suffragists were thrown against iron furniture. One woman had a heart attack and was refused medical care.

★★★★★

BY LATE NOVEMBER 1917, news of this brutal treatment began to shift public opinion in the women's favor. They were released from jail; soon all charges were dropped, and the Senate and the House took up the proposed amendment. Even Wilson started to thaw (two of his daughters supported the suffragists).

BY LATE NOVEMBER 1917, REPORTS OF BRUTALITY AGAINST WOMEN PROTESTERS BEGAN TO SHIFT PUBLIC OPINION IN THE WOMEN'S FAVOR.

None of the 12 states fully enfranchising women by then were in the South. Yet ratifying the amendment would require support from at least some of the southern states, where white supremacy ruled and black men had been effectively disenfranchised by local regulations. The language of the 19th Amendment echoed that of the 15th:

"The right of the citizens of the United States to vote shall not be denied or abridged by the United States or by any State on account of sex."

It did not guarantee anyone's right to vote, and Jim Crow laws, which enforced racial segregation, had proved that there were other ways to block access to the ballot box. "Everyone knows that the same impediments that are keeping black men from polls—poll taxes, literacy tests, understanding clauses, white primaries,

grandfather clauses—that these things are going to keep black women from the polls," says historian Martha S. Jones, author of the upcoming book *Vanguard: How Black Women Broke Barriers, Won the Vote, and Insisted on Equality for All*. "There's good evidence that the promoters of the 19th Amendment were counting on that assumption." They signaled to southern states that they had nothing to fear from women getting the vote: Whites would be enfranchised, and blacks still wouldn't.

Ratification of the amendment took more than a year, but on August 18, 1920, Tennessee pushed it over the finish line. The southern state did so by just one vote, that of a 24-year-old legislator named Harry Burn, whose mother had urged him to "vote for suffrage and don't keep them in doubt."

It was, at best, a qualified victory. Women had worked for more than 70 years to gain access to the ballot, and now they finally had it. But black women still faced nearly insurmountable hurdles to voting in the south. Native Americans—men and women—weren't even citizens until 1924; Chinese Americans had to wait until 1943. The real watershed moment for many minority women would be Congress's passage of the Voting Rights Act of 1965.

★★★★★

NINETY-EIGHT YEARS later, in 2018, the first majority-female legislature in the United States was elected, in Nevada. According to Democratic state senator Nicole Cannizzaro, that wasn't the intention. The parties were looking for the best candidates. But "when we were looking at candidates," she says, "we weren't discounting women. We weren't discounting their experience, and we weren't discounting their ability to come in and do the job." Cannizzaro ended up becoming the first female senate majority leader in the state's history.

Such an achievement was a long time coming. "The movement never put much emphasis on women gaining office," says historian DuBois. Instead, once the 19th Amendment was ratified, voting activists dispersed into other causes: the NAACP, labor unions, and peace organizations, to name a few. A lot of women—their energy spent from the movement and the war—dropped out of politics. Alice Paul and her colleagues at the National Women's Party switched to advocating for the Equal Rights Amendment, which was first introduced in Congress in 1923. The amendment was finally approved by the Senate in 1972 but was ratified by the required 38th state, Virginia, only this year, well past the 1982 deadline. The constitutional future of the amendment, which would "guarantee equal legal rights" for women and men, is unclear.

PASSAGE OF THE 19TH AMENDMENT WAS A QUALIFIED VICTORY. MANY NONWHITES—WOMEN AND MEN—STILL FACED HUGE BARRIERS TO VOTING.

At a high point during the 1920s, nine women served in Congress; those numbers didn't start inching up until the 1950s. The 2018 election saw the biggest increase in female representation since 1992. "We've made strides," says Debbie Walsh, director of the Center for American Women and Politics at Rutgers University, "but we're talking about less than a quarter of the members of Congress are women. We're at 29 percent women as state legislators." Twenty-six women serve in the 100-member U.S. Senate, and women are 101 of the 435 voting members of the House. One governor in five is female and, of course, there has not yet been a woman president or vice president.

The balance began to shift when women recognized they couldn't rely on political parties to recruit and fund female candidates. They needed to create their own organizations.

"We were just furious at how difficult it was to get our women elected to office," says Ellen Malcolm, who in 1985 founded EMILY's List, a group focused on getting Democratic women who favor abortion rights elected to office. "Over and over again, they'd be qualified, have a political base, have a success record or a track record," but they couldn't secure campaign funding.

EMILY's List bundled donations together to

Winter
BREEANNE

Youth activist

This is the first year that BreeAnne, a student at Howard University, will be old enough to vote for president. A veteran of several get-out-the-vote campaigns, the Riverside, California, teen has developed a program to promote civic engagement among youths. She wants them to understand that voting matters. "That's how we elect the people who represent us," she says. "If we aren't voicing our opinion that way, when we have the ability and not everybody is afforded that right, we are relinquishing a lot of political power."

throw behind candidates. (EMILY stands for Early Money Is Like Yeast; "it makes the dough rise," Malcolm says.) Eventually the organization also began training candidates and staffers. Rutgers and the Campaign School at Yale provide similar training that's nonpartisan.

Such foundational work has made it possible for the arrival of first-time congresswomen like "the Squad"—as the diverse quartet of liberal Democrats Alexandria Ocasio-Cortez, Ilhan Omar, Ayanna Pressley, and Rashida Tlaib are known—and enabled Pelosi's rise to become the most powerful woman in American politics. Clinton, also a Democrat, would not have won nearly 66 million votes in 2016 without such backing.

Republicans have some catching up to do. The party's female representation actually shrank in 2018. In the House, where Republicans have 196 seats, there are 13 women, while Democrats have 88 women. Among the 26 women senators, nine are Republicans and 17 are Democrats.

"From the Republican perspective, we're about 20 years behind the Democrats in terms of building the pipeline and infrastructure to support wider female races," says Ariel Hill-Davis, a co-founder of Republican Women for Progress, one of several groups recently created to support female Republican candidates. "There are more Gregs and Mikes in the Republican conference on the House side than there are women."

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REPRESENTATION MATTERS. Shortly after the 19th Amendment was passed, when women were just beginning to vote, Congress passed a law providing federal funds for maternal and child health care. Suffragists had led the way in lobbying for the bill, the first of its kind.

The suffragists wanted to break free from the subordinate role society had assigned them. But Susan W. Brooks, a Republican congresswoman from Indiana who was co-chair of the bipartisan Congressional Caucus for Women's Issues in 2017-19, holds up the traditional tasks that many women still fulfill as a reason for political involvement.

"They are often the person who is primarily responsible for health care in their family, the person who is responsible for eldercare, for care of parents, the person doing groundwork on childcare issues," she says. "They have a strong voice."

Brenda Lawrence, a Democratic congresswoman from Michigan who is co-chair of the caucus, runs through a litany of issues that she believes are being addressed only because women are at the table: sexual harassment and abuse, maternal mortality, raising the minimum wage, training women in skilled trades and engineering, and ensuring that clinical trials include women and their specific medical needs.

> WOMEN HAVE PUT ISSUES SUCH AS SEXUAL ABUSE, MATERNAL MORTALITY, AND THE MINIMUM WAGE ON THE TABLE IN CONGRESS.

"My role," she says, "is teaching women how to take on a position of power, a collective voice, in raising those issues."

It seems that each generation of women finds ways to exercise its collective voice. Much like the suffragists who gathered in 1913 before Wilson's inauguration, some 470,000 people descended on Washington in 2017 to support women's rights after Donald Trump's inauguration. Their signature pink hats may be gathering dust, but for many women the political awakening continues.

The suffragist legacy—the determination "to do and dare anything"—lives on in other ways too. Michelle Duster, a great-granddaughter of Ida B. Wells, raised $200,000 in small donations in 2018 to complete fundraising for a "people's monument" to Wells in Chicago.

"I never thought of myself as an activist," Duster says. "But so much time had passed that I thought, This has to be done." ▯

Rachel Hartigan is a *National Geographic* staff writer. This is photographer **Celeste Sloman's** first feature for the magazine. **Johanna Goodman** is a New York–based illustrator.

‘I AM SCARED ALL THE TIME’

AS UGANDA’S FOREST HABITATS SHRINK, HUNGRY CHIMPS ARE FEEDING ON CROPS—AND SNATCHING HUMAN CHILDREN. IT’S TESTING THE RELATIONSHIP BETWEEN PEOPLE AND A PROTECTED ANIMAL.

BY **DAVID QUAMMEN**

PHOTOGRAPHS BY **RONAN DONOVAN**

A chimp killed a toddler named Mujuni Semata in Kyamajaka in July 2014. After the family fled, chimps remained in the village—even staring at their reflections in the windows of the Sematas' vacant house.

PREVIOUS PHOTO

Near Mparangasi village, a boy fetching water pauses as a chimpanzee passes. In western Uganda small groups of chimps survive in remnant forest patches. Deprived of wild foods, they forage among crops and fruit trees, competing with people for sustenance, space, and survival.

LIFE WAS ALREADY HARD for Ntegeka Semata and her family, scratching out a livelihood on their patch of land along a ridgeline in western Uganda. They were barely producing enough to feed themselves and make a little cash, and now a group of hungry, bold chimpanzees threatened their sustenance, maybe even their safety.

The chimps had been coming closer for a year or two, roaming all through Kyamajaka village, searching for food, ripping bananas from the trees, grabbing mangoes and papayas and whatever else tempted them. They'd helped themselves to jackfruit from a tree near the Semata family's house. But on July 20, 2014, scary tribulations gave way to horror—a form of horror that has struck other Ugandan families as well. That was the day a single big chimp, probably an adult male, snatched the Sematas' toddler son, Mujuni, and killed him.

"A chimpanzee came in the garden as I was digging," Ntegeka Semata recalled during an interview in early 2017. Her four young children were with her as she combined mothering with hard field work, but when she turned her back to get them a drink of water, the chimp grabbed her two-year-old son by the hand and ran. The boy's screaming brought other villagers, who helped the mother give chase. But the chimp was rough and strong, and the fatal damage occurred fast.

"It broke off the arm, hurt him on the head, and opened the stomach and removed the kidneys," Semata said. Then, stashing the child's battered body under some grass, the chimp fled. Mujuni died en route to a regional hospital.

Things are still uneasy in Kyamajaka, for some people and some chimpanzees. Attacks on human infants have continued—at least three fatalities and half a dozen injuries or narrow escapes in the area. The main cause, it seems, is habitat loss for chimps in parts of western Uganda—forested lands outside national parks and reserves that have been converted to agriculture and cut for timber and firewood.

Demographic and landscape changes are happening fast throughout Kagadi District (which includes Kyamajaka), just east of Lake Albert and the Rwenzori Mountains, and in neighboring districts as well. The rich, volcanic soil supports a burgeoning number of families on small, private plots eking out a living from corn and cassava and fruits, with a little income from tobacco, coffee, sugarcane, and rice.

Ntegeka Semata comforts her two younger children, both born since their brother was killed. The family left Kyamajaka for an inadequate new home: a rented room, safe from chimps but with no land to farm. They later acquired a farmable plot and started over.

The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.

COLLISION COURSE

Having lost much of their forest habitat, chimpanzees resort to eating crops, sparking retaliation by humans. During the past three decades, chimps have also killed or injured villagers, terrifying communities.

Pakwach
Nebbi
MURCHISON FALLS NATIONAL PARK
KARUMA WILDLIFE RESERVE
BUGUNGU WILDLIFE RESERVE
BUDONGO FOREST RESERVE
Katama
Kirima
Masindi
Kasokwa Forest Reserve
Kasongoire
Dwoli-Bwenderu
Bulindi
Hoima
Lake Albert
KABWOYA WILDLIFE RESERVE
BUGOMA FOREST RESERVE
DEMOCRATIC REPUBLIC OF THE CONGO
Buyaga County
Kagadi
Nyakarongo Parish
Kyamajaka Village
Muhororo
SEMLIKI W.R.
ITWARA F.R.
Kyansimbi
Mubende
IBAMBARO FOREST RESERVE
SEMULIKI NAT. PARK
Fort Portal
Ruteete
Nutuli
KIBALE NAT. PARK
Mukichanga
KATONGA W.R.
Mt. Stanley
16,762 ft
5,109 m
RWENZORI MOUNTAINS NAT. PARK
Kasese
Lake George
U G A N D A
Rwenzori Mts.
GREAT RIFT VALLEY

Young victims
More than 40 attacks—most of them on children—were logged in western Uganda from 1990 to April 2020. Many more reported attacks are unverified.

- Death
- Injury
- Attack without injury

10 mi
10 km
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- Protected area
- Deforestation in chimp range, 2000–2018
- Dense forest
- Road
- Built-up area
- Cropland

SOREN WALLJASPER AND MATTHEW W. CHWASTYK, NGM STAFF; SCOTT ELDER
SOURCES: RONAN DONOVAN; VERNON REYNOLDS; RICHARD WRANGHAM; POLICE REPORTS; WORLD DATABASE ON PROTECTED AREAS; NASA EARTHDATA; UNIVERSITY OF MARYLAND; OPENSTREETMAP CONTRIBUTORS, AVAILABLE UNDER OPEN DATABASE LICENSE

The Uganda Wildlife Authority is acutely aware of the chimp situation, and although chimps outside protected areas (as well as within national parks and reserves) fall under the authority's responsibility, private forests do not.

"Unfortunately, it is hard for us—impossible for us—to prevent clearing of these areas," said UWA executive director Sam Mwandha. "We can only plead; we can only educate and hope."

But appreciating a forest for its long-term benefits, such as mitigating erosion and buffering temperature, can be difficult in the face of short-term pressures to grow crops for food. So the immediate need, Mwandha said, is to "create awareness" among people that their vigilance against chimps must be constant. To that end, the UWA deployed three rangers in the region and established a wildlife outpost to monitor chimps and help villagers learn to live with them.

The chimps of Kyamajaka—maybe just a dozen or so in the village environs—were nesting nightly in remnant woods or the nearby eucalyptus plantation. Because their wild foods had largely disappeared, they emerged by day to feed from the crop fields and fruit trees surrounding homes. They moved stealthily, mostly on the ground because there was no forest canopy left to swing along, sometimes coming into close contact with people. They drank at the same stream where village women and children fetched water, and when they walked upright, standing four feet tall, they seemed menacingly humanoid.

Chimpanzees, along with bonobos, are our closest living relatives. Their species, *Pan troglodytes,* is classified endangered by the International Union for Conservation of Nature. Their total population throughout Africa is at most 300,000, possibly far less. As adults, they're big, dangerous animals—a male might weigh 130 pounds and be nearly half again as strong as a similar-size man.

Chimps in productive forests live mostly on wild fruit, such as figs, but they will kill and eat a monkey or small antelope when they can, tearing the body to pieces and sharing it excitedly. Because chimps tend to be wary of adult humans, their aggressive behavior toward people, when it occurs, falls mainly upon children.

Chimpanzees in Uganda are protected by law: It's illegal to hunt or kill one. They're further protected by tradition of the Bunyoro people in western Uganda, who, unlike some Congolese across the border, don't hunt them as food.

For more than three years after the trauma of her son's abduction, Ntegeka Semata and her husband, Omuhereza Semata, continued living in their house. But Ntegeka couldn't work in the garden, and the children were sometimes too afraid to eat. "I am scared all the time that other chimpanzees might come back," Ntegeka said. By the end of 2017, the Sematas had fled and were living a marginalized existence in a rented room three miles away.

"I feel like we've been cast back into poverty," Ntegeka said after the move.

THE DEATH OF MUJUNI SEMATA was no isolated event. Police reports from the town of Muhororo (of which Kyamajaka is a satellite village with a few hundred families) describe two chimp-on-child attacks during 2017. On May 18 a toddler named Maculate Rukundo was seized in a cornfield while her mother worked the crop. A crowd of local people, soon joined by police, tracked the chimps to a patch of forest, where the little girl lay dead in a pool of blood. Five weeks later, chimps (possibly the same group) took a year-old boy from another garden plot, with his mother nearby. A posse of villagers pursued the chimps until they dropped the boy, who survived. More such incidents have been reported in the area.

From elsewhere in western Uganda have come similar gruesome accounts over the years: one child killed on the sugarcane plantation at Kasongoire, in 2005; four chimpanzee attacks on children, with one fatality, near the Budongo Forest Reserve, farther north; eight attacks in the 1990s, seven of which were probably by a single rogue male, near Kibale National Park.

Most cases involve chimps that are reckless at one fateful moment, not repeatedly. This has happened in chimp range across Africa, most notoriously at Gombe Stream National Park, famed primatologist Jane Goodall's study site in Tanzania where in 2002 an adult male chimp snatched and killed a human baby.

CHIMPANZEES AREN'T the only primates facing pressures. Despite law and custom, among communities of angry, powerless people in western Uganda who fear for their children, there have been killings of chimps too—retaliatory, defensive. Late in 2018, an adult male chimp was fatally speared,

Clearing of forests, by small farmers and giant sugarcane and tea enterprises, has shrunk chimp habitats to forest fragments such as this one on the Kinyara Sugar Works plantation, near a village called Kabango. According to a village elder, four children in the area have been attacked—and two killed—by chimps during the past decade.

and a young female was beaten to death with sticks and stones. All these painful ambiguities show up vividly at a place called Bulindi, where one group of chimpanzees and their fraught interactions with people are studied by a British biologist named Matt McLennan.

McLennan came to Uganda in 2006, as a doctoral student at Oxford Brookes University, in England, to study how chimps adapt their behavior to living in a human-modified landscape. He knew that the Budongo Forest Reserve was good habitat with some 600 chimps and that another forest reserve about 50 miles to the southwest, Bugoma, harbored roughly the same number.

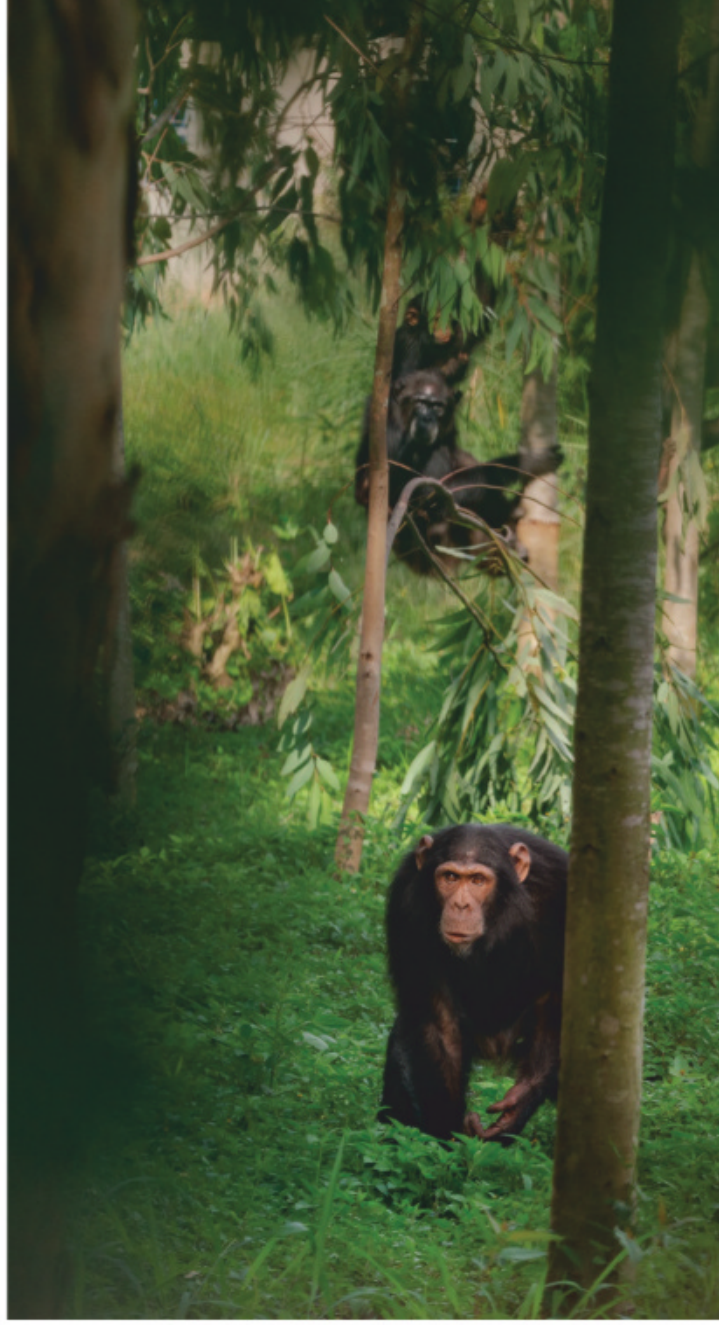
Between those two refuges was a mixed landscape of small farms and large sugarcane plantations, with a growing human population and shrinking patches of forest. About 300 chimps lived in that middle zone, finding refuge in the forest patches, venturing out from the forests onto croplands for food. Much of the land was private, and after passage of the 1998 Land Act, which formalized deeded property, people felt empowered to harvest their forests and switch to crops. Survival in such a landscape, for a single chimp or a group of them, was problematic.

This tangle of circumstances drew McLennan to Bulindi, about halfway between Budongo and Bugoma, where he found a group of at least 25 chimps. With Tom Sabiiti, a local research collaborator, he began to gather ecological data from indirect evidence such as fecal samples and nest surveys. It was difficult: Unlike wild chimps in good habitat, which tend to be shy, these Bulindi chimps had a menacing edge.

"We found out pretty quickly that they didn't like people inside the forest," McLennan told me. "Their strategy was to try to intimidate us, which they did very effectively."

The big males, especially, hooted, drummed on the ground, thrashed vegetation. But eventually the chimps came to tolerate the researchers, and the pair gathered data for two years. But clearing was under way, and the chimps were getting bolder. The first attack on a child, within memory of local people, occurred in 2007. The next year McLennan went back to England and wrote his dissertation. When he returned in 2012 to continue field research, things had changed.

Most of the forest was gone. Fields of corn, cassava, sweet potato, and other garden produce spread across the hillsides. There were fewer chimps in the local group, and fewer adult males.



Some decline may have been deaths from leghold traps, an illegal means of discouraging animals such as chimps and baboons from taking crops.

The remaining chimps seemed even bolder, especially around women and children. Their diet included more of the human crops, such as jackfruit, to the resentment of local residents. What McLennan has found is that the chimps at Bulindi are coping—for now. Their number has risen slightly, and to his surprise a young female showed up in late December 2019, the first time a migrating female has appeared in Bulindi since at least 2012. They're robust; most adult females have infants. Genetic analysis of the chimps' DNA—led by Maureen McCarthy at the Max Planck Institute for Evolutionary Anthropology and published in 2018—suggests that their isolation hasn't yet brought severe inbreeding.

But sometimes the Bulindi chimps carry higher levels of stress-related hormones than a population of chimps within the Budongo Reserve, just 20 miles away. Does that mean their

LEFT

Two months after the Sematas left their house, photographer Ronan Donovan set up nearby, and he says chimps visited every day for a week. They seemed enticed but agitated by their reflections in the windows, as if challenged by rival chimps living inside.

BELOW

Recovery has been difficult for Teddy Atuhaire, seen here at 17, who was a four-year-old in Mukichanga when a chimp carried her into a tree. The chimp gashed her head and broke her arm so badly it had to be amputated. Her parents are dead, her siblings far away. Atuhaire's aunts provide occasional help.

piratical way of life, staying so close to humans and foraging for their food, is inherently stressful? It's hard to know whether they're thriving on human foods or suffering tension from their nearness to people—or both.

Among the people at Bulindi, attitudes vary. Lillian Tinkasiimire, an amiable matriarch whose little redbrick house is graced with a mango tree in front and a fig tree behind, both of which attract chimpanzees, takes a steady view.

"The chimps are very clever," she said. "If you don't chase them, they will be your friend. If you chase them, you will see fire." Tinkasiimire has preserved much of her forest. Her attitude is, let the chimps live there, let them be, let them visit.

McLennan hopes to encourage such tolerance. He and his late fiancée, Jackie Rohen, created the Bulindi Chimpanzee and Community Project. (Rohen died of a pulmonary embolism in early 2020 in Uganda while continuing her work with McLennan.) The project provides development assistance to families and incentives to mitigate clashes between chimps and humans: payment of school fees in exchange for reforestation, starter plants for shade-grown coffee, stoves that use less firewood, borehole wells that allow women and children to avoid danger when fetching water at pools where chimps drink. The best way to preserve peace, McLennan and Rohen recognized, is to help Bulindi's chimps and people stay apart.

Chimps take corn, mangoes, papayas, and a favorite shown here, jackfruit, from villagers' fields and trees. This female and her youngsters belong to a group of 22 chimps marooned in a forest fragment along a stream corridor not far from Mparangasi. An infant clings to her belly while a toddler rides on her back.

AT KYAMAJAKA and other villages near Muhororo, three hours southwest of Bulindi, things are different. McLennan doesn't study these chimps, and no similar community project offers incentives to preserve forest or measures to defuse conflict. No one knows how many chimpanzees live in the Muhororo forest remnants (maybe 20, maybe fewer?) or where their next unfortunate meeting with humans may occur.

Half an hour's walk from Kyamajaka, photographer Ronan Donovan and I spoke with Swaliki Kahwa, whose son Twesigeomu (known as Ali) was taken by a chimp in 2016, before his second birthday—dragged away and fatally battered. Kahwa deferred to his elder brother, Sebowa Baguma Kesi, the village chairman, to tell us about it. Kesi, a grave but cordial man, produced a police report and showed us the postmortem photos. The boy's right arm had been nearly torn off; a gash on his groin may have cut the femoral artery; some of his fingers were broken. According to the times listed on the report, little Ali took almost 12 hours to die.

Kesi noted dryly that villagers have been taught to consider chimpanzees "beneficial"—that chimp-based ecotourism would bring visitors to the cornfields around Muhororo. "We don't see any benefit," he said. "It's killing our children."

The national reserves, such as Budongo and others, with sizable chimpanzee populations, are a problem of one sort for the UWA. Those areas are degraded by illegal woodcutting, cropping, and settlement, with which the agency, in partnership with the National Forestry Authority, deals firmly. Some illicit settlers are even evicted from the reserves. But for chimp-human conflict within communities such as Kyamajaka,

UWA's approach is gentler. Executive Director Mwandha says the steps taken to create awareness of the immediate dangers and potential benefits of chimpanzees amid villages are having some success. In Kyamajaka, Norah Nakanwagi, the village chairwoman, had told Donovan and me that the solution was to take the chimps away. "Not to kill them. But take them away."

WHY NOT MOVE the chimps? Yes, people ask about that, McLennan told me. But move them where? There's no vacant chimpanzee habitat anywhere in Uganda. And dropping them into habitat occupied by other chimps would provoke chimpanzee war. Another dire option: Kill the chimps to protect the people. But no one is likely to advocate that as official policy. A third option: measures such as starter coffee plants, stoves that use less firewood, reforestation incentives, borehole wells, alternate sources of income, patience, sympathy.

It's a local problem that's not just local. Uganda's dilemma foretells the future of chimpanzees across Africa. What makes a village like Kyamajaka seem so pitiable, and a town like Bulindi seem so important, is that in those two places the future has arrived. ▯

David Quammen's 16 books include *Spillover: Animal Infections and the Next Human Pandemic.* **Ronan Donovan** made the transition from field biologist to photographer after spending a year in Uganda researching chimps.

INSTAGRAM

YANE KANG

FROM OUR PHOTOGRAPHERS

WHO

Kang is an otter enthusiast and wildlife photographer in Singapore.

WHERE

Singapore's public Bay East Garden overlooking the city's famous skyline

WHAT

Taken with an iPhone 7

Otters were once nearly extinct in Singapore's rivers, but decades of environmental restoration have helped the frolicsome animals return. One morning while Kang walked along the city's Marina Bay on the lookout for the water mammals, a popular group of otters known to locals as the Bishan family was swimming and feeding near the shoreline. Kang chose a spot on the path and waited. It took 20 minutes, but finally the family arrived and began to swim and play directly in front of her.

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Tapanuli Orangutan *(Pongo tapanuliensis)*

Size: Head and body length, approx. 68 - 130 cm (27 - 51 inches) **Weight:** Approx. 40 - 90 kg (88 - 198 lbs) **Habitat:** Lowland and mid-elevation hill and submontane forest **Surviving number:** Estimated at fewer than 800

Photographed by Tim Laman

WILDLIFE AS CANON SEES IT

A call says it all. The male Tapanuli orangutan uses his specialized throat sac to produce a booming call with a dual purpose: to warn off rivals and attract mates. Each female answers the call only once every five to ten years, as she spends about six years caring for her young. With the longest interval between births of any mammal and a small population, this great ape is vulnerable to habitat loss, hunting for food and illegal trade, and conflict with farmers over crop-raiding. Last call may be near.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.

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THE INSIDE STORY ON

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